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Modern Glass Factory Equipment

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To the average person, glass is just glass from a tiny bead to a casket, but the chemists and engineers engaged in its production know that there are endless varieties of this substance in chemical composition and quality, and that constant research is being made in order to produce qualities best suited for the intended purposes and to reduce the costs of manufacture.

As the production of glass in all branches involves the action of heat upon the batch ingredients, the furnace is the progenitor in the art and although the oldest of all classes of equipment, its design is by no means standardized nor perfect and it is even today one of the most engrossing and perplexing subjects with which glass manufacturers have to deal.

The high degree of heat demands that furnace and pot walls be made of a highly refractory substance and a good grade of fire clay is the only material known up to the present time which is practicable in furnace construction. There are other materials which are more highly refractory, such as compressed carbon and graphite and clay mixtures, but these have the disadvantage of being better heat conductors and of introducing discoloration in the glass due to their slow disintegration and carbon content.

Unfortunately, or perhaps fortunately, fire clay is largely composed of one of the chief ingredients of glass—silica—and sooner or later the tank blocks are carried away via the lehr route in the form of finished product.

In recent years there has been a general feeling that the quality of the flux blocks in the side walls and bottom of tanks has deteriorated, reports being common that tank furnaces which formerly had continuous runs of from twelve to eighteen months or more now often fail with three or four months' service.

It is very likely that in many cases poor quality has much to do with the short life of the blocks, but it should be remembered that there are other causes such as increased temperature, larger proportion of fluxes, and heavier tonnage melted, these latter conditions being due to the growing desire on the part of manufacturers to largely increase their production without going to the expense of furnace enlargements.

If these conditions reduce the life of the block fifty per cent, as a conservative estimate, the very high cost of tank furnace walls renewals and time lost in shut-downs are doubled and would go far even in one year towards enlarging the tanks.

Where producer gas is used the tendency is to build wide tank furnaces, almost square in some instances, in order to provide a longer path across the furnaces for the better combustion of the slower burning gas. Lower and wider port openings are also recommended in order that the burning gas may spread more uniformly over the molten glass, and furthermore to permit the lowering of the crown. If a crown arch five feet above the metal line at its center should be lowered eighteen inches the effects of heat radiation at that point will theoretically be a little more than doubled.

Cooling the side walls by low pressure air jets is the general practice and this cooling method owes its virtue solely to increased radiation. Now a twelve-inch block of fire clay is a pretty fair heat insulator—witness the plug in the furnace peep hole which, although red hot on one end, may be handled by the bare hands on the other end.

It is reasonable then to affirm that no amount of surface cooling during the first few months after reblocking will greatly affect the wearing away of the blocks during that period. It is very probable that within a month or two the first three or four inches leave the inside surface of the blocks, and, acting upon this assumption, some tank builders have laid up their side walls with 8-inch blocks. Of course longer life for the 8-inch blocks can not be claimed, but if they last as long, or almost as long, as the 12-inch blocks, their lower cost will justify their use.

Experience shows that cooling the surface of the blocks by air jets, or otherwise, is by no means the determining factor in the life of the blocks. Instances are common where well-designed cooling systems have been installed at heavy expense, both in first cost and for power to drive the fans, in spite of which the life of the blocks was much shorter than those in other tanks having much less expensive and sometimes poorly designed cooling systems. In such cases

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it becomes necessary to assume that other conditions, such as the amount of flux, furnace temperature and melting tonnage were the ruling factors.

After the walls have worn down to two or three inches in thickness, and oftentimes still less than this, cooling becomes most effective, in which case even a short stoppage of the fan or water cooler means trouble and plenty of it. Where it is at all practicable, duplicate driving units should be installed; for example A.C. and D.C. motors, used singly but quickly interchangeable. When the situation reaches this stage however, and if there are no rush orders on hand, the practical manager will run off the molten glass and reblock the furnace in the shortest shut-down period possible.

The glass furnace under the best conditions at present obtainable is a woeful heat waster, 60 per cent of the heat in the gas being lost by radiation, and about 10 per cent being utilized in melting the batch. With very thin side walls the radiation losses are much greater with a correspondingly heavy increase in the cost of gas per ton melted, and this item must have due consideration when determining as to the time for reblocking.

As the cost of fuel is on a steady advance and is not likely to decline to anything near the pre-war level, the glass manufacturer will extend the glad hand to the furnace builder and the refractory block builder who will reduce the present enormous heat losses and costs of reblocking.

The designing and building of tank furnaces cannot at present be termed a highly developed art. Nearly all of them are built along the same general lines, using the regenerative principle, and under the same operating conditions there is probably no great superiority of one design over another.

A radical departure in design seems to offer the only hope of improved efficiency. Experimental furnaces on an adequate scale are costly affairs and furnace builders do not construct them at their own expense. There exists but little restriction in design on account of patents and in the interest of fuel conservation the large factory owners should pool their interests and divide the expenses in conducting research work in furnace design.

Cooling Systems

In factories producing hand made articles, a statement frequently heard is that the best investment that can be made in such factories is in the fans and piping for providing liberal amounts of cooling air. In concurring with this statement another can be made which is no less true:—the greatest waste of power must be charged against these air cooling systems, both on account of faulty design and in the constantly recurring neglect to keep closed the outlets where air jets are not required. It is very difficult to convince many employees that the closing of the outlets in the piping system reduces the load on a centrifugal fan. It is also difficult to impress upon them the fact that air has weight and inertia, and that it requires considerable expenditure of power to move it in the large volumes required. A 4-inch open nozzle in an air duct with a pressure of five inches water gauge will pass 1,124,640 cubic feet of air in 24 hours at an energy expenditure of 31 horsepower hours, which means a dead loss of 62 cents on the conservative basis of two cents per horsepower hour.

In plants using hand presses the air for cooling the molds and ware is most efficient at from five to eight inches water gauge, some cases requiring higher pressure, with the air jets issuing from comparatively small nozzles.

For furnace cooling lower pressure and large volume with the air split up into a large number of nozzles is generally conceded to be the most efficient installation. The nozzles should be placed from four to six inches from the furnace blocks, pointing slightly upward, and the jets should impinge directly upon horizontal joints in the furnace walls and at intermediate points.

In many cases continuous horizontal pipes with slots and with single connections to the main duct are placed along the side and end furnace walls. This is very bad practice for the reason that the sections of the long slotted pipe farthest from the feeder pipe get little air and what little there is becomes considerably heated before reaching the furnace blocks. The horizontal nozzle pipes should be divided into sections not over four feet long, each section with both ends capped and with a fan-shaped pipe connection at its center.

These 4-foot sections should be connected in vertical rows to a sub-feeder pipe and groups of three or four of these brought together in easy angles and led through a main feeder to a main duct.

It is not good practice to place large mains under or over the furnace walls with vertical feeders leading off at right angles to each nozzle pipe, as this arrangement involves the conversion from static to velocity head at a sacrifice of efficiency.

Water cooling at the most vulnerable points, as at the junction of the dog house with the main walls, and around the throats, has been used with success, and sometimes the combination of water and air cooling have given good results.

In regard to the piping systems for air cooling, many existing plants are designed for efficient operation while, on the other hand, many are just the reverse.

Some years ago it seemed to be the prevailing idea that air for cooling purposes should be *preheated,* at least that is the impression one gets upon seeing the main piping suspended in hot air currents over furnaces, ports, glory holes, and other hot places. In some factories there are perhaps no other locations available for these mains but in new layouts favorable locations should be provided. The mains for cooling furnaces and machine molds should invariably be led and distributed under the working floor, preferably in a basement where they are accessible, and better still under the basement floor in the form of concrete ducts, with sheet metal risers to the various points requiring air.

A very important point to be considered in designing air distribution layouts is the maintaining of ample size in the mains and branches, holding air velocities down to 3,000 feet per minute or less except at the nozzles. In order to maintain uniform velocities, thereby promoting efficiency, the mains should be reduced in size wherever a branch is taken off, in proportion to the volumes carried. Many designers prefer to figure pipe sizes upon the basis of uniform resistance per foot to the passage of the air, in which case

the combined cross-section areas of the branches is considerably greater than that of the main which supplies them. All Y branches should lead off at not more than 45 deg., less than that is better, and elbows should be made on long radius. Air pockets and obstructions inside the piping, as well as leaks should be avoided.

Fans

Practically all the fans used in glass factories are of the centrifugal type, with small high speed motor driven direct-connected units predominating.

The installation of a fan with independent air distributing system for each furnace is quite common and has many advocates. This type of installation has three distinct advantages which may be summed up as follows:—first, the high speed permits direct coupling to an electric motor making the most efficient form of drive; second, very large and long mains are avoided; and third, a fan or motor breakdown affects only the furnace to which that particular unit is serving.

These three advantages seem weighty enough at first sight to definitely settle the question as to the best type of installation but, in the opinion of the writer, there are disadvantages which outweigh the above named good qualities. In comparison with a large slow speed belt driven fan serving from two to six furnaces the disadvantages of the small independent high speed units are as follows:—first, the small units cannot operate as efficiently as the large one having the same peripheral speed; second, the high speed fans are much more liable to fail on account of hot bearings, lubrication being more difficult to maintain; third, the several small fans invariably waste more oil; fourth, the small fans are in most cases necessarily located inside the furnace room and near the furnaces where it is difficult to provide cool clean air at their intakes; and fifth, the small units cannot have 100 per cent over-capacity to take care of an emergency demand on account of a breakdown of an adjacent fan without greatly reducing their operating efficiency under normal load, while the large fan needs no over-capacity.

The question now logically presents itself, would not the situation be far more serious in case the large fan became disabled than it would be if one, or even two, of the small units were in like condition. It certainly would, and the discussion would stop here were it not for the fact that the liability of the large fan itself to become disabled is remote enough to outweigh this disadvantage. Cases are on record in the mining regions where fans of this description have operated for several years, day and night, without having had to be stopped on account of necessary repairs being required. In the writer's experience with a large number of mine fans, covering a period of ten years, there is not recalled a single instance of a fan break-down. Motors burn out occasionally, especially those running on direct current, and these require frequent repairs, but with duplicate sets, quickly interchangeable, there is little likelihood of serious fan stoppages on that account.

Another argument against the direct-connected fan and in favor of the belt or chain drive on the large fan is that the latter may easily be reduced or increased in speed by simply changing either or both pulley diameters, and varying furnace conditions make this a feature of considerable importance. In this connection variable speed motors are impracticable on account of their reduced efficiencies and other inherent disadvantages when running at other than their normal speeds.

In speeding up fans it is well to remember that with unchanged outlets the horse power required varies as the cube of the fan speed; thus, doubling the speed requires eight times the horsepower.

In figuring the size of fan required the conditions and requirements are so variable that no definite rule can be given. In practice it has been found that a tank furnace having a melting capacity of 50 tons in 24 hours, and a surface of 500 square feet to be cooled, can be effectively cooled with 45,000 cubic feet of air per minute at a total head of 4 inches water gauge.

In determining the size of the motor required to drive any fan, the following formula is used:

$$\text{H.P.} = \frac{\text{C.F.M.} \times \text{W.G.} \times 5.2}{33000 \times \text{per cent fan efficiency}}$$

where C. F. M. represents cubic feet per minute and W. G. the total head in inches as read on the water gauge. Taking the mechanical efficiency of the fan at 70 per cent, the motor for the above named 50-ton tank furnace would have a rating of 40½ brake H. P., using the above formula.

It is important to install the water gauge connections correctly as otherwise the readings will have little value.

A small pipe, ¼-inch to ½-inch, connected to a pocket in the main duct where the air has no velocity, will give a correct reading. If placed in the main where the velocity is high, the same pipe connection will give a much lower reading, and in this case a Pitot tube, which gives the total head, should be located at about the center of the main not less than 20 feet from the fan.

In selecting a fan it is well to get one whose rating is but little in excess of the requirements, as running under capacity means reduced efficiency. Ring-oiling bearings, liberal in size, are essential and they should have soft packing around the shaft, or some other means to prevent the oil from being carried into the fan by the strong air currents. The shaft should have extensions on both ends to provide for duplicate motor drives.

Disc fans, while low in cost, are not suitable on account of their low mechanical and manometric efficiencies.

In designing a fan and piping system the question may be asked: Why not install several small fans with each discharging independently into the main duct of an interconnected distributing system? The answer is that this plan will not work in practice for the simple reason that a decreased pressure in the main near one fan will cause it to be overloaded, and an excess pressure will cause underload with no air delivery.

It is difficult to get good working action from even two fans connected in parallel to the same main, for a slight difference in their pressure outputs will shift a large part of the load to the fan producing the higher pressure.

The Production of Colorless Glass in Tank Furnaces

With Particular Reference to the Use of Selenium. Part I*

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The production of colorless glass in tank furnaces several years ago in America passed out of the experimental into the commercial stage. In this country colorless glass had only been made up to three or four years ago in pot furnaces. There has, however, been a rapid development in the use and manufacture of colorless glass containers and the demands of the public have already led, and will lead in the future, to the conversion of former green glass tank furnaces into those producing colorless glass.

The success of the process has been made possible through the introduction of selenium, either in the form of elementary selenium, or as a salt such as sodium selenate or selenite. Selenium differs in its action from manganese dioxide in several ways, more particularly, however, for the reason that it functions in the presence of reducing agents, whereas manganese dioxide requires just the opposite conditions. The atmosphere of a tank furnace is, therefore, not normally very suitable for manganese dioxide, although to a limited extent it is applied. For selenium, however, tank furnace conditions are appropriate.

One of us has very frequently, during the past three years, been consulted as to the methods to be adopted in order to obtain colorless glass in a tank furnace, and the reply has been in all cases that there is no species of magic by which the result can be accomplished, the prime requisite being the use of pure materials, carefully controlled, so that the iron oxide should fall below a certain very small value. Having obtained such pure materials, they should be stored and mixed under conditions such as will prevent impurities from gaining access to them. The most important factor concerned, as will clearly be brought out in this paper, is the total amount of iron oxide present in the glass, and if this is maintained well within the limits set out, success is not difficult to attain.

To illustrate the process a little more concretely, the following batch composition is typical of most of those in use both in America and in this country, namely:—

Sand	1000 lb.
Limestone or limespar	180 to 200 lb.
Soda-ash	350 to 400 lb.

If the sand contains not more than 0.03 per cent of iron oxide and the limestone not more than about 0.06 to 0.08 per cent, the amount of selenium required is usually in the neighborhood of half an ounce per 1,000 lb. of sand. There must also be added a very small amount of cobalt oxide, which may lie between one-sixth and one-eighth of the weight of the selenium, that is, between one-twelfth and one-sixteenth of an ounce.

In stating this batch composition it must clearly be understood that the adjustment of the selenium and of the cobalt oxide will have to be made from time to time to suit the particular conditions. Thus it is still possible to decolorize sand which contains 0.05, 0.06 and even 0.07 per cent of iron oxide, provided the other batch materials are reasonably pure. It may, however, be found necessary to use distinctly more selenium. Cases are known, indeed, where the amount of selenium added may exceed 2 or 3 oz. per 1,000 lb. of sand. In such cases, however, a first-class colorless glass is not produced.

The question remains as to what is the limit for the amount of iron oxide present, in order that decolorizing shall fall just within the points of possibility. We shall answer this more completely in the experimental section of this paper, but we may say that from a number of analyses carried out in this laboratory of commercial glassware, the upper limit may be placed in the neighborhood of 0.1 per cent of iron oxide. We have found the glass still to be practically colorless at 0.11 per cent, but when in excess of this value the green tinge is quite noticeable; indeed, it may just be detected in thick glass when 0.1 to 0.11 per cent of iron oxide is present. Should an attempt be made to decolorize a glass containing considerably in excess of 0.1 per cent, the result is very unsatisfactory, the glass acquiring a muddy color which may be either green-, yellow-, or even black-looking. It must be clearly understood that for satisfactory decolorizing the total iron oxide content must not at the outside be more than 0.10 per cent, and it is clearly obvious that the glass will be so much the better the smaller the iron oxide value below the limit.

From the above statements, which are based on ordinary practice, it will be clear in the first place that very careful control is needed, and, secondly, that we have to do with very small quantities; for example, on the one hand of iron oxide, and on the other of selenium and cobalt oxide added. It is to the study of the amounts of these substances in so far as they are affected by a number of different factors that this paper and subsequent ones will be devoted. For example, one of the questions asked at the recent meeting at Leeds concerned the effect of salt-cake on the possibility of decolorizing with selenium. It was stated that as a matter of practice difficulty had been found in obtaining decolorizing in the presence of salt-cake. It will also be noted that in the batch referred to above no reference is made to salt-cake. Very frequently an entirely soda-ash batch has been used. In other cases where salt-cake is added the amount is very small. One of the problems which we set ourselves was to ascertain what is the effect of salt-cake.

In addition to this factor there are others, some of which we have already pursued investigations on and still others which must await solution. Thus, the relative value of selenium and of sodium selenite constituted a problem in itself. Further, the function of white arsenic, which is a frequent addition, also needs to be elucidated, and thirdly, the effect of reheating and of cooling in the annealing oven. Reference is made to these subjects in what follows.

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THE GENERAL CONDITIONS OF EXPERIMENT

The experiments were carried out on a small scale, and this must be borne in mind when applying the results to practical operation in large furnaces. One of the sources of iron oxide in the finished glass arises from the corrosion of the fireclay receptacle, whether it be the tank-blocks in a tank furnace or the crucible in a pot furnace. In the small pots used the area of fireclay surface exposed to the action of the glass was relatively very much greater than in the normal large tank furnace, and this must be borne in mind. Nevertheless, very definite principles are obtainable from our meltings and apply equally to the more practical operations. Indeed, in cases where we have been able to make comparison, the small scale results are in close agreement with commercial practice.

The standard batch was as follows:—

Sand (Fontainebleau)	100 parts
Soda-ash	37 "
Limespar	20 "

The iron oxide in each of these three chief batch materials was determined, with the result that the sand was found to contain 0.016 per cent, the limespar 0.05 per cent, and the soda-ash 0.01 per cent.

As a decolorizer, selenium or sodium selenite was employed. The particular form is stated in the tables given below. The unit amount of selenium was 0.003 part per 100 of sand, and multiples of this amount, namely, 1, 2, or 4 times, were used in various experiments. This unit amount, namely, 0.003, corresponds with half an ounce per 1,000 lb. of sand, so that the other quantities can readily be reduced to the same basis.

Cobalt oxide was added to all the batches. At first an amount equal to one-sixth of the selenium was used, but it was found that when the content reached 0.002 part of cobalt oxide per 100 of sand, a distinct blue color was obtained. The best results occurred when the cobalt oxide added represented 0.0005 of a part per 100 parts of sand, and this amount was adhered to throughout the series of meltings.

The time taken for the complete melting operation was three to three and a half hours. The temperature was maintained constant at a particular value, some meltings being made at 1370° to 1380°, a few at 1400°, and a series at 1440°. These tests enabled one to ascertain to some extent the effect of temperature on the color. In all cases slabs of glass were poured from the meltings and the test-pieces were annealed in a closed muffle furnace and subsequently examined for color and analyzed for iron oxide content.

THE PERCENTAGE OF IRON OXIDE IN GLASS CAPABLE OF BEING DECOLORIZED BY SELENIUM.

In the study of this problem, not only purely soda-ash batches, but also others containing salt-cake were tested. In the latter, 1, 2, and 4 parts of the soda-ash were substituted by salt-cake, so that the four batches compared were as follows:—

	1.	2.	3.	4.
Sand	100	100	100	100
Limespar	20	20	20	20
Soda-ash	37	36	35	33
Salt-cake	—	1.35	2.7	5.4
Cobalt oxide	—	0.0005	0.0005	0.0005
Selenium or sodium selenite	—	as required	as required	as required

The data and the general results summarized in Table I were obtained when melting was carried out at 1380°.

In Table II meltings were made of a somewhat similar character but at a higher temperature, mainly 1440°. A few further meltings at 1380° are included of glasses which were very distinctly green in color.

In the set of glasses tabulated in Table II the depth of color increased with the iron oxide content.

When all the results in Tables I and II are considered it is possible to state fairly accurately the limit of iron oxide content which may be neutralized by means of selenium or sodium selenite. The actual amount of iron oxide dissolved from glass to glass unfortunately differed distinctly, and it will readily be seen that the higher values, that is, the greener glasses, were those made at the higher temperature of 1440° and particularly those which contained salt-cake.

TABLE I.

	Parts of decolorizer per 100 parts of sand.				
No. of sample.	Selenium.	Sodium selenite.	Parts of salt-cake	Per cent of iron oxide	Color
2	0.003	—	0	0.07	Decolorized
3	0.003	—	0	0.06	"
8	0.006	—	0	0.07	Brownish-yellow
154	0.012	—	0	0.08	Deep amber
59	—	0.0065	0	0.08	Amber
68	—	0.0131	0	0.08	Deep amber
77	0.012	—	1.35	0.04	Very slightly over-decolorized
78	0.012	—	2.7	0.04	" "
79	0.012	—	5.4	0.04	" "
19	0.012	—	1.35	0.11	Faint green
22	0.012	—	1.35	0.08	Decolorized
53	0.012	—	1.35	0.11	Faint green
20	0.012	—	2.7	0.08	Decolorized
21	0.006	—	5.4	0.08	"
10	0.006	—	1.35	0.08	"
36	0.006	—	1.35	0.11	Very faint green
29	0.006	—	2.7	0.11	Faint green
45	0.006	—	5.4	0.10	Very faint green
58	0.006	—	5.4	0.10	" "
4	0.003	—	1.35	0.11	Pale green
5	0.003	—	2.7	0.10	" "
6	0.003	—	5.4	0.11	" "
74	—	0.0262	5.4	0.11	Very faint green
69	—	0.0131	1.35	0.09	Decolorized
141	—	0.0131	1.35	0.06	Very slightly over-decolorized
70	—	0.0131	2.7	0.07	Decolorized
60	—	0.0065	1.35	0.10	Very faint green
61	—	0.0065	2.7	0.09	" "
116	—	0.0065	2.7	0.09	Decolorized

TABLE II.

	Parts of decolorizer per 100 parts of sand.					
No. of sample.	Selenium.	Sodium selenite.	Parts of salt-cake.	Temp. of melting.	Per ct. Fe_2O_3	Color.
31	0.006	—	0	1440°	0.08	Pale straw
65	—	0.0065	0	1440°	0.09	" "
26	0.006	—	1.35	1440°	0.12	Pale green
28	0.006	—	1.35	1380°	0.14	Green
67	—	0.0065	5.4	1440°	0.14	"
43	0.012	—	2.7	1380°	0.14	"
42	0.006	—	2.7	1380°	0.14	"
93	—	0.0065	5.4	1380°	0.14	"
12	0.006	—	5.4	1380°	0.15	"
14	0.003	—	1.35	1440°	0.15	"
25	0.003	—	5.4	1440°	0.15	"
73	—	0.0131	5.4	1400°	0.16	"
66	—	0.0065	5.4	1440°	0.16	"
27	0.006	—	5.4	1440°	0.17	"
33	0.006	—	5.4	1440°	0.18	"
15	0.003	—	2.7	1440°	0.22	Bright green

It will be seen that in practically all cases a glass containing up to 0.09 per cent of iron oxide was capable of

being decolorized. In some cases, indeed, over-decolorizing results, such as in the case of glass No. 65, occurred.

It will further be seen that when the amount of iron oxide reached 0.10 a faint green tinge became apparent in the pieces examined. The thickness of these pieces varied between three-sixteenths and three-eighths of an inch. In the usual bottle thickness for medical bottles probably this very faint green color would not be noticed. Undoubtedly, however, with 0.11 per cent of iron oxide the green color began to be apparent and, in all cases tested, as the percentage more and more exceeded 0.10, the green color became more and more intense. We may therefore fairly put the limit of iron oxide capable of being decolorized by selenium at 0.09 per cent, with a possible further allowance of 0.01 per cent in commercially produced glass.

THE EFFECT OF SALT-CAKE ON THE DECOLORIZING ACTION OF SELENIUM

The results already set out in Tables I and II also quite clearly demonstrate that the addition of salt-cake has a definite effect in the decolorizing action of selenium. In other words, it is easier to decolorize a batch in which soda-ash is the only source of alkali than when a proportion of salt-cake is present. No attempt has so far been made to test a batch containing salt-cake but no soda-ash; it is quite apparent that even a small proportion of salt-cake makes a difference, plainly seen, for example, when comparison is made of the glasses Nos. 154 and 77. The former was made from a soda-ash batch, the latter from a batch containing 36 parts of soda-ash to 1.35 of salt-cake. Twice as much iron oxide was present in No. 154 as in No. 77; yet, with the same amount of selenium added, the former glass was much more over-decolorized than the latter; in other words, less selenium is required to obtain colorless glass when the latter is made wholly from soda-ash than when salt-cake is present.

The analysis of the causes why the salt-cake batch should need more selenium or sodium selenite than the soda-ash batch is not perfectly easy from the data obtained. Two factors, however, appear to stand out as the most important ones in operation.

The first of these causes seems to lie in the greater corrosive action of the batches containing salt-cake as compared with those containing soda-ash only. Such comparatively greater corrosive action was not always found (compare, for example, glasses Nos. 154 and 77), but, generally speaking, the higher percentages of iron oxide were to be found associated with the salt-cake glasses. Examination of Table II furnishes clear evidence to this end. And if salt-cake generally brings about an increase of iron oxide content, more selenium will be needed for decolorizing.

This increase in the amount of selenium needed when salt-cake is present seems to be due to another reason besides its action in increasing the iron oxide content. Attention has already been directed to the fact that when salt-cake is present, as in glasses Nos. 77, 78 and 79, the presence of 4 units of selenium was not so excessive as in the case of glass No. 154, which contained twice as much iron oxide. Moreover, it will be noticed that in glass No. 8, made without salt-cake, 2 units only of selenium produced a brownish-yellow color when 0.07 per cent of iron oxide was present. There must clearly be some action between the salt-cake and the selenium such as does not occur between sodium carbonate and selenium.

In this connection it is interesting to note that in dilute acid solution at 100°, colorless sodium selenite reacts with sulphur dioxide to give selenium itself, the reaction being represented by the equation:

$$Na_2SeO_3 + 2SO_2 + H_2O \rightarrow Se + Na_2SO_4 + H_2SO_4$$

The phenomenon of loss of decolorizing power when salt-cake is present suggests that at higher temperatures, such as exist in the glass furnace, this reaction is reversed and selenium oxidized by the salt-cake.

In order to test the point qualitatively, pure sodium sulphate was melted in a platinum crucible in an atmosphere of carbon dioxide, and selenium dropped on to the surface of the liquid. The great difference between the temperature of vaporization of selenium (680°) and the melting temperature of salt-cake (885°) rendered quantitative observations by this method useless, but distinct qualitative results were obtained. It was observed that, as the selenium touched the surface of the salt-cake, the layer in contact with the molten salt instantaneously turned white and then sank and dissolved in the liquid, while the bulk of the selenium rapidly vaporized. After several additions, the salt-cake was cooled, dissolved in water, and filtered (to insure that no elementary selenium was present). The clear, colorless solution was boiled, hydrochloric acid added, and a current of sulphur dioxide passed through it. In all cases the solution became pink and several milligrams of selenium were precipitated.

Whether 0.5 or 5 grams of salt-cake was used, almost the same amount of precipitated selenium was obtained. On filtering, boiling down with hydrochloric acid, and again passing sulphur dioxide, no further precipitation of selenium occurred. This proves that the action between salt-cake and selenium actually occurs at high temperatures with the production of sodium selenite, a colorless salt, but with no formation of sodium selenate. When the two substances are in solution in the molten glass it is probable that the action will much more readily occur than when the substances are merely brought together in a platinum crucible.

In the production of the glass, therefore, it seems evident that the loss of decolorizing power of the selenium, observed when even a small amount of salt-cake is present, is due, not only to the higher iron oxide content usually arising owing to corrosion of the fireclay, but also to the production of colorless selenite.

THE COMPARATIVE DECOLORIZING ACTION OF SELENIUM AND SODIUM SELENITE

Both elementary selenium, either red or black, and sodium selenite are used in commercial work for decolorizing purposes, as well as for the production of ruby red glasses.

The disadvantage which has usually been associated with the elementary selenium is that it vaporizes at a comparatively low temperature, resulting always in a loss of the material. Such loss due to volatilization was certainly detected in our experiments by the smell of selenium when the batch was charged into the hot pots.

In order to obtain some definite data by which to compare

the efficiency of selenium and sodium selenite, comparative meltings were carried out with the standard batch already set out, containing soda-ash only as the source of alkali and no salt-cake.

Since sodium selenite contains 45.7 per cent of selenium, the amount of selenite equivalent to 0.003 part of selenium is 0.0065, and this quantity we may also refer to as one unit (that is, the equivalent of ½ oz. per 1,000 lb. of sand). The amount of cobalt oxide present was 0.0005 part and the temperature of melting 1,380°. Table III states the results.

TABLE III.

No. of glass.	Wt. of decolorizer per 100 parts of sand. Selenium.	Sodium selenite.	Resulting color.
154	0.012	—	Deep amber
8	0.006	—	Brownish-yellow
9	0.006	—	" "
151	0.006	—	Pale straw
2	0.003	—	Decolorized
3	0.003	—	"
68	—	0.0131	Very deep amber
59	—	0.0065	Deep amber
125	—	0.0033	" "
148	—	0.0033	" "
126	—	0.0017	Fairly deep amber
149	—	0.0017	" " "
127	—	0.0008	" " "
150	—	0.0008	" " "
156	—	0.0004	Amber
159	—	0.0002	Faint straw
162	—	0.0002	Faint green

Our experience showed that, with selenium, decolorizing was readily obtained by one unit (that is, by 0.0003 part or ½ oz. per 1,000 lb. of sand). This result was obtained when the glass contained 0.07 per cent of iron oxide and is in fairly close accord with results obtained in large tank furnaces. Two units of selenium (0.006 part or 1 oz. per 1,000 lb. of sand) when the iron oxide is about 0.07 per cent, are, from our results, clearly excessive, while 4 units (0.012 part) yield an amber color. We may remark that some manufacturers have, in their early attempts to produce colorless glass, obtained amber tints. The reason, in the cases we have been called to investigate, has been the use of excessive amounts of selenium.

In regard to sodium selenite, there is no doubt at all that, under the conditions of experiment, it was much more powerful as a decolorizer than was selenium. Indeed, it has been found somewhat difficult to add a *small enough* amount to obtain decolorizing. In two experiments it will be noted that with 0.0002 part the residual color was a faint green in the one case, in the other a faint straw; that is to say, the sodium selenite required for decolorizing a wholly soda-ash batch was in the neighborhood of 0.0002 part, or only about 1/64 oz. per 1,000 lb. of sand. Any quantity in excess produced an amber color.

Such a result is remarkable, and it is difficult to associate the much smaller efficiency of the selenium with a wholesale loss by volatilization. What the volatilization loss is we cannot conjecture, but we propose to carry out experiments whereby to test the amount.

Nor can we at the present time clearly understand, if selenium loses its efficiency when salt-cake is present through conversion to selenite, as we have already suggested, why sodium selenite itself in a soda-ash batch should be so remarkably efficient. The two results at first sight appear contradictory. How far the efficiency of either is influenced by a reducing atmosphere or by the addition of white arsenic we have yet to ascertain, and experiments are proceeding on these lines.

Finally, it may be desirable to point out again that this apparently great discrepancy in decolorizing power between selenium and sodium selenite does not hold good when the batch contains salt-cake.

THE POSSIBILITY OF COLOR CHANGE DURING ANNEALING OR RE-ANNEALING

It is the usual practice in decolorizing with manganese dioxide to arrange that the glass, when worked from the pot, shall be slightly high in color, that is, shall show a faint pink tint, as the subsequent annealing always causes slight reduction. As the result, an article which goes into the annealing furnace with a slight pink tinge is usually found to be better decolorized than one which is placed in the lehr apparently already decolorized.

It seemed of interest, especially in view of several statements that selenium glass also shows color changes, to make a number of tests on the point.

In the tests we have made the sample pieces were already cold and the study has been rather of re-annealing than of the ordinary slow cooling down process which commercial articles mainly receive.

The series of tests was carried out in an electrically heated tube furnace. Selected pieces with a known color were placed in the furnace and heated at a series of different temperatures, namely, 500°, 525°, 550°, 575°, 600°, and 625°, three different periods of heating being applied, namely, one, three, and six hours. The colors of the samples used are stated in Table IV.

TABLE IV

No.	Initial color.	No.	Initial color.
15	Bright green	36	Very faint green
14	Green	60	" " "
12	"	2	Decolorized
42	"	10	"
4	Pale green	22	"
5	" "	13	Pale straw
6	" "	31	" "
26	" "	8	Brownish-yellow
29	Faint green	59	Amber

At each particular temperature the samples were examined at the end of each of the periods stated.

No change was observed in the first sixteen samples at any temperature or at the end of either one, three, or six hours' heating. The last two glasses, however, both became perceptibly deeper in tint even after one hour at 525°, and the increase of color reached a maximum with three hours' heating. With increase of temperature to 550°, the intensity of color produced also increased. Above this point, the color change on heating again diminished until, at 625°, no difference between the initial and final colors could be observed. From our experiments, it is evident that no color change takes place in a selenium-containing glass unless a fairly deep selenium tint is initially present. In such case the maximum deepening effect occurred at about 550°. The decolorized sample of glass was found to undergo no change.

In view of the fact that, in practice, ruby colored selenium

glasses are usually produced by reheating the colorless or straw-colored glass, our results are perhaps a little surprising, although the development of a deeper color in the already colored samples is in accord with practical experience. But it is to be noted that the conditions inside an electrically heated tube furnace are slightly different from those inside the ordinary lehr, where the atmosphere is most likely reducing in character. It is possible, therefore, that under such conditions color changes would take place such as we have not found. We propose to make some further tests under reducing conditions. Moreover, since the glasses had already been annealed and our heating process was really the process of re-annealing, we propose to carry out observations in which the hot samples of glass after being poured are cooled down slowly at different temperatures such as would obtain in the ordinary lehr.

It may be pointed out that the conditions inside the electric tube furnace are very much those which would exist inside the muffle lehr now fairly commonly used.

SUMMARY

(1) A large number of small scale meltings have been carried out to determine the relative effect of selenium and sodium selenite as decolorizers both in salt-cake batches and in others free from salt-cake. The meltings were carried out mainly at 1,380° but some also at 1,440°.

(2) The maximum percentage of iron oxide in the glass which it is found possible to decolorize either by selenium or by sodium selenite is 0.09. A further allowance of possibly 0.01 per cent may be made in commercially produced glass, but the smaller the iron oxide content below 0.09 the better the glass in appearance.

(3) The presence of salt-cake even in only very small amounts in the batch calls for an increased amount of selenium for decolorizing purposes.

(4) The ordinary soft bottle glass batch containing a small proportion of salt-cake appears to be more corrosive of fireclay material than the corresponding soda-ash batch. Consequently the amount of iron oxide present in the glass is increased and decolorizing is less easy.

(5) There is evidence that elementary selenium reacts with salt-cake at high temperature and is to some extent converted into sodium selenite.

(6) In batches containing soda-ash only, sodium selenite appears to be very much more effective in decolorizing action than elementary selenium. Whereas ½ oz. of selenium per 1,000 lb. of sand is required with the ordinary soft bottle glass batch, an amount only of 1/64 oz. of sodium selenite is found to be sufficient under the conditions of our experiments.

(7) When selenium-containing glasses are reheated it appears that color changes only take place in those glasses which have been over-decolorized; that is to say, in which there is a distinct selenium tint. The effect of reheating is to deepen the tint, and this change occurs perceptibly at a temperature of 525° and still more effectively at 550°. At still higher or at lower temperatures the color change is not distinctly observed.

Further experiments are proceeding to ascertain the relative value of selenium and of sodium selenite as decolorizers; to test the influence of reducing agents, including white arsenic, and to study further the effect of annealing.

DISCUSSION

MR. E. A. COAD-PRYOR said that the question which Prof. Turner had raised was very important, and he would like to ask him first of all how much arsenic was introduced into the batch in addition to the selenium. It was scarcely clear to him that Prof. Turner's explanation could be the whole story, because one would rather expect the effect of the salt-cake on the selenium to be proportional to the amount of salt-cake that was added. If the salt-cake were doubled, he would expect to find that the selenium was destroyed, or at least rendered inert. The most exciting part about the experiments appeared to be that the selenium was rather fugitive in the lehrs in the same way that manganese was. But it was fugitive in rather a tricky way. There was a critical temperature around which the color went pink, and below which it went green. He was not prepared to say just what that temperature was, but it was surprisingly low, and it might be possible, by an ingenious manipulation of the lehrs, to prepare that color favorably. In that connection it would be extremely interesting to know whether Prof. Turner had noticed that the rate at which the color went up or down varied with the salt-cake and also with the arsenic. He (the speaker) was inclined to think that it did, but it would require further experiment. Comparing the results of work on a tank with small scale melts in the laboratory, he had not found so much divergence as Prof. Turner would lead one to expect. With regard to the difference of the behavior of a glass which was cooled in the ordinary way—that is, the article after being made was passed through the lehrs—as compared with a glass which was cooled quickly in a small melt and reheated, he had found the results, as a rule, fairly parallel. Further information with regard to the influence of the salt-cake on the fugitiveness of the color would, he thought, be of extreme value.

MR. W. P. JOHNSON said he would like to ask Prof. Turner if he did not think there might be another explanation for the large amount of selenium that was required as the salt-cake increased, namely, the fact that salt-cake was a very crude product, and therefore included a large amount of iron oxide in the salt-cake itself, as well as bringing in iron oxide along with the reducing agent which was added in order to reduce the salt-cake. If Prof. Turner were to make some tests concerning the amount of iron oxide in the salt-cake itself the matter might probably be cleared up altogether.

MR. W. J. REES said there was probably another cause of the increase in the color of the salt-cake batches. It might be due, not to iron dissolved from the pot, but rather to the alumina dissolved from the pot. A very common source of color in salt-cake batches was due, not primarily to the iron compounds, but to the formation of alumino-sulpho-silicates, somewhat analogous in composition to ultramarines. He would suggest that this was a possible adjunct to the deepening of the color of the glass rather than the iron. It would be interesting to know if there were any information available from the tests which had been carried out as to the

influence of furnace atmosphere on the behavior of the selenium. The question as to whether an atmosphere was oxidizing or reducing very often had a definite influence on a given problem. It would be very interesting, therefore, to know whether any information bearing on this point had been elicited from the experiments.

MR. A. COUSEN, in reply to the questions asked, said he would like to point out that white arsenic was not added to any of the batches. An endeavor had been made to maintain the batch as simple as possible in composition, so as to make it easy to trace the effect of the different factors. In regard to the salt-cake, it was a very pure sample, containing little more than a trace of iron oxide. All the other materials were of good quality. The glasses had not been analyzed for alumina content, so that a precise answer to Mr. Rees's question was not possible. When the iron oxide in the glass was high, the color was found to be bluish-green. Whether or not the alumina affected this color he could not say. In regard to the greater amount of selenium needed for decolorizing salt-cake-containing batches, the amount did not increase in proportion to the increase in salt-cake; and only a very little more selenium was needed for the batch containing 5.4 parts of salt-cake as compared with that containing 2.7 parts. The greatest difference was observed between the wholly soda-ash batch and the one with a small amount of salt-cake. Various other points had to be considered yet, but the investigations were being continued.

PROF. TURNER said that Mr. Cousen had replied to most of the questions asked. He would now merely observe that they had at Sheffield conducted other investigations which would be able to solve the problem of the bluish-green color in glass. Of this more would be reported at a later date. In regard to Mr. Johnson's remark as to impure salt-cake being the cause of the greatly increased selenium required to decolorize the salt-cake-containing batches, the suggestion was quite untenable. A little reflection would show that, in view of the small amounts of salt-cake added, it would have to be a very poor sample indeed to add any noticeable amount of iron oxide to the glass. As Mr. Cousen had pointed out, the salt-cake used contained practically no iron oxide.

Firing of Ceramics in Electric Furnaces*

By E. L. SMALLEY†

The application of electric furnaces in the ceramic industries affords an opportunity for the betterment of the product, to an extent not less remarkable than the achievements in the metal industries. The perfect control of temperature, cleanliness of atmosphere, and even distribution and uniformity of temperatures have shown in industrial applications on a large scale that the electric heat is practical and gratifying in this field.

Commercial glassware can be annealed electrically to a perfection not possible in any fuel-fired furnace. The success of such an electric furnace installation depends upon the correct form of furnace combined with a suitable method of handling. One glass manufacturer installed a furnace for annealing goblets and fruit jars. The furnace was 22 inches wide by 120 inches long by 60 inches high, (55 x 300 x 150 cm.) and was fitted to an over-head I-beam conveyor already installed for handling the ware. An attempt had been made to use the conveyor for annealing by natural gas but without success.

It was shown that the conveyor was impractical on account of excessive heat losses where the conveyor was in contact with the furnace, but the remarkable annealing effect of electric heat was fully attested. Sixty-five test goblets were taken at random from the top, bottom, sides and centers of the several trays of the conveyor supporting the goblets. The goblets were subsequently tested in a spectroscope. Sixty-four were A-1 grade, showing no internal strains; the sixty-fifth goblet was B-1 grade. Grade C-1 was considered a passable grade.

In the manufacture of bi-focal lenses, electric furnaces have reduced the percentage of rejects and losses from 18 to 20 per cent in gas furnaces to 2 or 3 per cent in the electric. Rejects and losses in the gas furnaces were due to over-fusion; cracking; lack of complete fusion and internal strains. Losses in electric fusions are due principally to inherent defects in the lenses. The saving has been effected due to the cleanliness of the atmosphere; to the uniformity and control of heat, and to the ability of the electric furnace to produce a tapered heat where required.

At the plant of a manufacturer in New York State, sixty furnaces are installed for the fusing of bi-focal lenses. The critical heat of fusion is about 775°C., and a tapered heat is necessary to prevent rupturing the lenses which would occur with heat too suddenly applied. All of the sixty furnaces are about 8 inches wide by 5 inches high and 14 to 18 inches long, (20 x 12.5 x 35 to 45 cm.) arranged in 15 batteries, each battery consisting of four furnaces to form a combined length of about 72 inches (180 cm.) per battery.

The lenses are set on plaques, four to a plaque, and conveyed continuously through the furnaces. The two furnaces at the entering end are equipped with one automatic temperature control. Each of the last two furnaces of the four in the battery are similarly equipped. As each battery of furnaces turns out approximately $1,800 worth of lenses per day, the saving of about 16 per cent in the reduced losses, is large interest on the investment.

The improper application of electric heat should be carefully guarded against. The release of heat must be from the correct direction with respect to the charge. It must be so distributed in its source that no overheating at any part will result. The more surface of the heating chamber covered by a source of heat, the more successful will be the application.

Electric furnaces as constructed today, when properly selected as to their design, are entirely dependable for ceramic firing at any temperature up to 1,100°C.

*Abstracted from a paper presented at the meeting of the American Electrochemical Society in Montreal, September, 1922.

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The Laboratory

By J. B. KRAK

Gaseous Fuels

The most important problem of the glass maker is undoubtedly the fuel question and as time goes on its solution becomes more and more difficult, in spite of the steady advances made in the utilization of fuel during the past quarter of a century. Since gas is the most convenient, as well as the most efficient form of fuel for the glass industry, it is little wonder that the localities where natural gas is available have become the centers where factories have been located. With the exhaustion of the older gas fields of Ohio, Pennsylvania and West Virginia a change from natural gas to some form of artificial gas, or the removal of the factory to one of the more recently discovered gas fields has become a question to be considered by executives. As long as glass factories were of comparatively crude structure such a removal could be accomplished without entailing a ruinous expense. The tendency of late years, however, has been the construction of such substantially built plants that it has become impossible to abandon them.

The intimate acquaintance of glass makers with gas and the many advantages of gaseous fuel have stimulated the development of various means of conversion of solid and liquid fuels into gas, and there exist at the present time a number of well established processes, each yielding a commercial gas of somewhat different chemical composition and heating value. From time to time there appear newspaper reports of entirely new methods of making gaseous fuel. Some of these reports are not confined to the daily press—which might be excused for seizing upon every item of news, however unfounded—but appear in trade papers, which should be more critical. In most cases inventors or promoters claim to produce a gas, by various means, which contains many times the energy originally present in the material from which it is derived. Sometimes the process takes the form of a dissociation, electrical, chemical or catalytical, of water with the formation of hydrogen and oxygen. Such a mixture would be an ideal gas, were it not for the fact that precisely as much energy is needed for the dissociation as is yielded by subsequent combustion. Claims of this sort are constantly made, sometimes without intention of fraud, but evidently through ignorance of some of the most fundamental laws of nature, and a great deal of money has been lost by those who invested capital in such schemes.

In order to have clearly in mind the distinguishing features of the more common commercial gases, it may be useful to briefly outline their principal characteristics, which depend chiefly on the nature of the raw materials used and on the methods of their conversion into the gaseous form.

NATURAL GAS.—Obtained by boring wells similar to oil wells. Composed chiefly of methane and ethane. The cheapest and most efficient fuel. Heat value about 1,000 B.t.u. per cubic foot.

COAL GAS.—Made by destructive distillation of bituminous coal in externally heated retorts. Consists mainly of methane and hydrogen. Primarily made for domestic use. Calorific power about 600 B.t.u. per cubic foot.

COKE OVEN GAS.—A by-product from the manufacture of coke. Of similar composition as coal gas but somewhat lower in heating value.

WATER GAS.—Made by the decomposition of steam by carbon at high temperatures. The gas, consisting of about 50 per cent hydrogen and 40 per cent carbon monoxide is made by an intermittent process, as the coal must be blown with air at frequent intervals to bring it back to incandescence. Heating value about 300 B.t.u. per cubic foot.

PRODUCER GAS.—Made on the same principle as water gas, but by a continuous process; a combination of the two operations used in the making of water gas. Contains about 50 per cent nitrogen, derived from the air, 20 per cent carbon monoxide, 12 per cent hydrogen and small amounts of methane, ethylene, oxygen and carbon dioxide. Heat value about 150 B.t.u. per cubic foot.

When burned with 20 per cent excess of air and assuming that the escaping gases have a temperature of 500° F., 1,000 cubic feet of gas will evaporate the following number of pounds of water:

Natural gas	893 lbs.
Coal gas	591 "
Water gas	262 "
Producer gas	115 "

For convenient reference, the following table is here inserted, showing what may be considered average volumetric analyses, and the weight and calorific value of 1,000 cubic feet of the four types of gas used for heating and illuminating purposes:

				Producer Gas	
	Natural Gas	Coal Gas	Water Gas	Anthra.	Bitum.
Carbon Monoxide, CO	0.50	6.0	45.0	27.0	27.0
Hydrogen, H	2.18	46.0	45.0	12.0	12.0
Methane, CH_4	92.6	40.0	2.0	1.2	2.5
Ethylene, C_2H_4	0.31	4.0	...	...	0.4
Carbon Dioxide, CO_2	0.26	0.5	4.0	2.5	2.5
Nitrogen, N	3.61	1.5	2.0	57.0	55.3
Oxygen, O	0.34	0.5	0.5	0.3	0.3
Pounds in 1,000 cu. ft.	45.6	32.0	45.6	65.6	65.9
B.t.u. in 1,000 cu. ft.	1,100,000	735,000	322,000	137,455	156,917

NATURAL GAS.—Gas is in many cases associated with oil. Wherever oil is found there usually is at least a little gas, but at times gas occurs alone. That gas and oil are closely related in chemical composition is evident from the fact that the gases given off by petroleum are similar to those predominating in natural gas. Conversely, some components of natural gas can be converted by compression and refrigeration into "casing head gasoline," which is added to heavier kinds of gasoline to make the resultant mixture more volatile.

In composition natural gas consists chiefly of methane or marsh gas, but higher members of similar hydrocarbons, such as ethane and olefine, are also frequently present in small quantities, as are carbon monoxide, carbon dioxide, hydrogen, nitrogen, oxygen and hydrogen sulphide. Gas

found in Kansas, Texas, Ontario and Alberta contain small amounts of helium. The following table shows to what extent differences in chemical composition occur in various gases.

Source of Gas	Methane CH_4	Ethane C_2H_6	Carbon Dioxide CO_2	Nitrogen N	B.t.u. per cu. ft
Texarkana, Ark.....	96.0	0.0	0.8	3.2	1.022
Noblesville, Ind.	86.8	6.2	0.8	6.2	1.040
Leavenworth, Kan.....	91.3	4.5	0.8	3.4	1.066
Erie, N. Y.	79.9	15.2	0.0	4.9	1.134
Columbus, Ohio	80.4	18.1	0.0	1.5	1.193
Guthrie, Okla.	69.4	20.6	0.1	9.9	1.062
Pawhuska, Okla.	66.5	20.7	0.3	12.5	1.093
Fort Worth, Texas ..	51.3	10.4	0.1	38.2	740
Bow Island, Canada...	87.6	0.9	...	11.2	...

The gas obtained at Fort Worth, Texas, contains about 0.9 per cent helium which is being separated at the United States Government plant at Petrolia, Texas. The Canadian gas contains 0.33 per cent helium. Unusual geological conditions, but little understood, result in gases containing large percentages of nitrogen, hydrogen sulphide or carbon dioxide, all of which tend to lower the heating value of the gas. Hydrogen sulphide is normally not a constituent of natural gas but is frequently encountered in gases in the Gulf Coast territory. It is generally accepted that hydrogen does not occur in natural gas.

Oil and gas are with few exceptions always found in sedimentary rocks. They may occur in separate beds, or in different parts of the same bed, having accumulated in the pore space of rocks or in cavities. In many cases the rock is a porous sandstone (Pennsylvania, West Virginia), occasionally gas occurs in porous limestone (Ohio, Indiana) or in shales (Colorado, California). The portion of the formation which holds the gas is known as the gas pool. If the containing strata are horizontal, the gas is usually irregularly scattered, but if tilted or folded, and if the porous beds are capped by a practically impervious formation the gas collects at the highest point possible. This observation was first made by I. C. White, State geologist of West Virginia, who developed what is known as the Anticlinal Theory.[1] This theory has made possible the discovery of numerous oil and gas pools throughout the Appalachian region. According to this theory gas collects at the top of the fold, with oil immediately below on either side, followed frequently by salt water.

Munn[2] has advanced the theory that the accumulation of gas and oil are due to hydraulic action. According to the "Hydraulic Theory" the diffused oil and gas are concentrated into pools by currents of underground water which forces them into the more porous beds. The oil and gas, according to this view, are not held in pools because of an impervious cap rock but on account of overlying and surrounding ground water.

Natural gas usually occurs under pressure which may amount to several hundred pounds per square inch. As more wells are drilled and the gas is piped away the rock pressure of a gas field diminishes. Orton[3], in a study of the Ohio and Indiana fields, found that the rock pressure was the same as that of a column of water whose height was equal to the difference in elevation between the level of Lake Erie and the strata in which the gas occurs. He therefore concluded that rock pressure is due to hydrostatic pressure. While this theory is applicable in many localities, it fails to explain the great pressure shown in many shallow wells. Some West Virginia wells have shown a pressure of 1,100 pounds per square inch and at one time engines were run by utilizing the rock pressure in the place of steam. This wasteful practice, however, has been prohibited by law.

It is usually necessary to compress gas from lower pressures to about 650 pounds per square inch for transmission through long pipe lines.

In 1775, George Washington dedicated to his country as a national park a tract of land in West Virginia, containing a burning spring. The first discovery of natural gas by drilling in the United States was made through the drilling of shallow wells for salt water in Ohio and West Virginia, early in the 19th century. The first actual use of natural gas for illumination occurred in Fredonia, N. Y., in 1826 but it was not until 1872 that gas was used for domestic purposes in Titusville, Pa.

In recent years the practice of removing the light gasoline vapors, mostly butane, pentane and hexane, has become almost universal where large supplies are available. High pressure gas from new fields contains relatively little gasoline vapor. The highest yields are obtained from low pressure gas associated with oil. The claim is often made that the removal of casing head gasoline does not lower the heating value of the gas. It has been proven, however, that the extraction of gasoline may lower the fuel value as much as five per cent.

Many theories have been proposed to account for the origin of oil and gas. With the same evidence before them, different scientists have arrived at contradictory conclusions. The theories advanced may be divided into two classes: those ascribing oil and gas to an inorganic origin, and those regarding them as the result of the decomposition of organic matter. The inorganic theory has been propounded by Berthelot and Mendelejeff. It is now quite generally held by geologists that oil and gas have been derived from organic remains, both animal and vegetable, which were buried in sedementary rocks at the time of their formation. Investigations of the optical activity of oil show it to be of organic origin, since optical phenomena are not shown by inorganically synthesized petroleum. The popular name of methane, namely, "marsh gas," is evidence of its derivation from decaying vegetable matter. Coal, as is well known, generates methane in such quantities as to constitute one of the great dangers connected with coal mining.

[1] Geol. Soc. Amer. Bull. III: 187, 1892.
[2] Ohio Geol. Survey, VI, 60.
[3] Econ. Geol. IV, 141, 509 (1909).

Fluorspar Investigations

The importance of fluorspar in the steel and ceramic industries is so great, and accurate information on methods of mining, milling, and utilization, and on costs of production and possibilities of future production is so lacking, that it has been considered advisable by the Bureau of Mines to investigate all phases of the fluorspar industry in the United States. At the request of, and in company with several eastern fluorspar producers, examination has been made of the principal fluorspar deposits of the western states. This examination was followed by an intensive study of the producing mines in Illinois and Kentucky. It was found that most of the deposits in the far western states were small and could not be relied on to produce much surplus over the needs of the western states. Costs of production in the Illinois-Kentucky field have increased greatly, owing to the increasing depth of the principal mines and other causes.

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CLASSIFIED BUYERS' GUIDE, PAGE 14

"WHAT is genius but an insatiable appetite for something better, a settled habit of meeting every *can't* with a *why?*"

An Industry Which Needs Reforms

The coal strike has ended. But among consumers of coal there is a widespread feeling of dissatisfaction with the way in which a settlement has been reached. It is felt that the fundamental causes of the conflict between miners and operators have not been removed. The adverse conditions which brought on the disastrous strike remain and it is feared that in time there will be a repetition of the calamity which has resulted in such a serious setback in the slow and painful process of return to normal conditions.

Great as is the cost of the struggle, it would have been worth the price if a satisfactory solution had been found of the problems with which the coal mining industry has been confronted for many years. Since no real reforms have been inaugurated it is clearly the duty of the Federal Government at Washington to create an agency to deal with the situation, having powers to enforce its decisions; a body modeled after the Interstate Commerce Commission. Existing governmental machinery has demonstrated complete inability to cope with conditions as they exist now, and have existed for years in the coal mining industry. Manufacturing, commerce, human life itself, is dependent upon coal to such an extent that the present depredations should bring a realization of the fact that no group of people have the right to withhold from their fellow men one of the prime necessities of life. Since the coal mining industry cannot, or will not reform itself, it must be coerced from without. When industry is threatened with paralysis and the health of millions is put in jeopardy, it is time for the government of the people to assert its just rights.

The truth is that government institutions have not kept pace with the growth of the country. Of the plethora of laws which are showered continually upon the nation too many are restrictive rather than constructive. It is one of the disheartening features of our political system that about the time men have developed to carry out the tasks for which they have been chosen they are thrown in the political scrap-heap. Extravagant and wasteful as we are with our natural resources, nothing can compare with the loss to the nation of the services of many of its foremost intellects through the abuse of the party system. Moreover, the legislatures suffer from an overdose of the legal mind. There is a demand for more engineers, more business men in the halls of Congress. The country needs less of precedent and more of vision. It will be only when the constructive type of mind can be brought to bear upon national problems that a solution may be expected of some of the present day perplexities.

Important Books on Glass Forthcoming

Formal announcement has been made that a series of works on the applied science of glass technology edited by Professor W. E. S. Turner of the School of Glass Technology, Sheffield University, England, will be published at an early date. The first volume, by Professor Turner, will be "Historical and General: An Introduction to the Study of Glass Technology." "Annealing of Glass," by S. English, M. Sc., will be ready shortly and "Glass Furnaces, Their Design, Construction and Operation," by Morris W. Travers, D. Sc., is in course of preparation. Further particulars will be given in a

later issue regarding these and other titles which will follow including: "Raw Materials of the Glass Industry," "Refractory Materials for the Glass Industry," "Melting of Glass," "Machinery for Glass-Making and Its Operation," "Physical Properties of Glass," "Graduation, Calibration and Testing of Glasss Instruments," and "Manipulation of Glass by Hand."

Technical Consultation Service

THE GLASS INDUSTRY invites its readers to refer to this department any problems with which they may be confronted pertaining to raw materials, glass technology, laboratory and factory practice. While making no pretensions to the possession of unbounded knowledge or infallibility THE GLASS INDUSTRY is ready to assist its readers to the best of its ability in solving their problems. Readers who can offer better suggestions are invited to submit them.

Questions should be submitted in writing and will be answered by mail as promptly as possible. The sources of all inquiries will be held in strict confidence.

Question (35).—Glass tubing drawn from fluorspar or borax. Would you be so kind as to furnish me the name and address of some person or company who could supply glass tubing drawn from fluorspar or borax or other vitreous substance which is free from silica. I am also very anxious to obtain a glass which has a melting point slightly below that of quartz but considerably above that of the ordinary refractory glasses, such as pyrex or Bohemian.

This material is to be used in research work carried on by the Government and it is very important to our project that we find some one who can supply it. The quantity needed will not be great but we would gladly pay extra charges for a special order.

I know of no one else on whom to call for this information and if you can help us in this way your kindness will always be remembered with greatest appreciation.

Answer.—A number of years ago a material made from fluorspar and known as Fritsch's glass was brought out in Germany and attracted quite a little attention, but very little or nothing practical has been done with it. We understand that a reference to this material was made in *Physikalische Zeitschrift* about twelve or fifteen years ago.

At the present time we are informed that the Cooper-Hewitt Electric Company, Hoboken, N. J., are making fluorspar "glass" which is used for joining tubes of different melting points, such as quartz and pyrex glass down to lead glass.

A chemist who has done considerable experimental work with fluorspar states that in making Fritsch's glass the material must be melted in platinum crucibles and if cast it must be done in platinum molds. The operation is very destructive to the platinum.

Letters to the Editor

Some Interesting Comments

To the Editor of THE GLASS INDUSTRY:

The article in your recent issue describing the new plant of the United States Sheet and Window Glass Company, at Shreveport, La., was an exceedingly interesting one. The descriptive detail of the mechanical lay-out was very timely, but the points of especial interest to the writer are those discussed on pages 174-5.

It is interesting to know that, instead of glass working "lively" or "dead," to use the terms of the old hand blowers, we now say that the viscosity is low or high, and that so many molecules of CaO are to be added, or the temperature of the glass body is to be raised or lowered so many degrees. It is too much to hope that this matter has yet been reduced to infallible formula. It is nevertheless true that in so far as that result is obtained, so near are we approaching to a continuously efficient process of mechanically handling glass.

Some six or seven years ago Mr. A. L. Field, then of the Bureau of Mines, published in connection with other workers, values for the viscosity of blast furnace slag as determined by the torsion method. Mr. A. E. Williams and myself had been working on this same problem as applied to glass, by measuring the rate of penetration of a rod of known cross-section and weight. The results were by no means comparable in accuracy to the method of Field, and he was kind enough to repeat some of our measurements using his apparatus. Since that time, considerable work has been done on this subject, both published and unpublished, and considerable knowledge must now be available as to the effects of composition and temperature on that factor. Just how these data are applied to the manufacturing operation is of course the crux of the matter. Steel buildings are not built by the method of trial until one is finally constructed of sufficient strength that it does not fall down under the conditions of service. Glass fabricating devices are, however, usually so developed. In one case, the full properties of the material and the laws connecting those properties are known; in the other they are not.

Statements made in that article relative to the pyrometric equipment used are of interest. Reference to the Pyrometer Volume of the American Institution of Mining and Metallurgical Engineers, of comparatively recent date, will show that the potentiometer system both indicating and recording, and the disappearing filament optical pyrometer, have for some years been used extensively in glass manufacturing.

Several plants are known to the writer where this equipment has been in use for between five and six years, and with marked success. The disappearing filament optical is particularly applicable to glass melting furnaces, and gives good results in the hands of either the technical man or the master teaser—who is quite often a technician of the highest order.

A much easier method of checking black-body conditions in any part of the melting furnace, than the use of thermocouples as described in the article, is the use of closed tubes. A tube closed at one end, inserted into the glass body or into the part of the furnace desired, furnishes a check of highest possible accuracy on the temperature indications as given by the optical sighting on the open bath or furnace wall. The principal matter, however, is not one of variation from the absolute values, but the constancy of that variation, as this is the point which determines the practicability of the method. Where not in contact with glass, an iron pipe welded shut or closed with a cap, is usually sufficient. Care must be taken that the interior of this tube is free from oil, or any material which will give rise to smoke or fume in the tube. For checking purposes in glass, the clay room can quite cheaply make up some tubes of coarse batch. Tubes so used should be not less than 1½ inches inside diameter, to permit easy and accurate focusing of the optical, and of a length suited to the place in which they are to be employed.

This offers a much easier and fully as accurate a method of checking black-body temperatures, under glass tank conditions.

S. F. Cox,
Chief Engineer, Calorizing Company of Pittsburgh.
628 Haverhill St., Wilkinsburg, Pa.
September 20, 1922.

Some Impressions Obtained on a Recent Visit to Certain Glassworks in France and Belgium

To the Editor of THE GLASS INDUSTRY:

At present the glass industry in Northern France is chiefly concerned with one subject—reconstruction. To cite one instance, I might refer to the situation in which one of the largest of the French plate glass works, the Compagnie des Glaceries de St. Gobain, have found themselves since hostilities ceased. Faced with factories ruined, not merely by shell-fire and the bombardment incidental to artillery warfare, but integrally and thoroughly ruined by premeditated destruction carried out with characteristic German method, faced also with the task of repopulating an area from which many thousands of families had been driven by the ravages of war, their task has not been an easy one. Through the great kindness of the president of the company, I was enabled to visit the new factory now practically completed which the

company have erected at Compiègne. Later I was given the opportunity of viewing the reconstruction in progress throughout much of the devastated area, visiting in particular Noyon, Chauny, Tergnier and St. Quentin. Particularly was I impressed with the work that American citizens are doing in these regions. At Compiègne, the works layout, effected on practically virgin soil, approaches towards the ideal. The construction is almost entirely in ferro-concrete, illumination and air are well-provided for, and from the public health point of view the works should be as satisfactory as such a factory can possibly be.

Having regard to the repopulation of the devastated regions, I was interested, from the economic point of view, in the attitude taken by the manager of another large factory, a bottle works. "I want children," he said to me, "future glass blowers. A man comes to me for work. I ask him if he is married and if he has any children. If he has four or more children I take him, pay the fares of the family to X—— and give him a house there with 300 square metres of ground. After 20 years with the company we give him some more ground and he can then become 'petit rentier' and retire modestly to the tillage of his fields. We can do this because we already own the ground. Les Francais," he added, "aiment beaucoup la terre."

"But why 300 square metres with the house to begin with," I asked. "Because," was his reply, "less would not be worth while, 300 square metres wisely planted is sufficient to pay to a man and his family good dividends in the form of fruit and vegetables. A larger area he could not attend to without neglecting something else—his work.

"The father of a family, who are living on the spot, is usually a good workman. Married men with families are not so likely to be influenced by strike agitation except when the cause is very just. Again landlords and owners of property are not liable to become Bolshevists. As to the factory," he went on, "we must train our own men and boys for we shall work by machinery."

The percentage of ash in the fuel used both in France and Belgium approaches values to which we in England are quite unaccustomed, yet I did not see one rotating bottom producer in any of the works I visited. The fuel used is quite often lignite with bituminous coal. A fair amount of the coal used in Belgium has been obtained from England. At one particular factory the fuel used was about half-and-half English bituminous coal and lignite.

In my opinion there should be a good market in France and Belgium for mechanical producers and producer plants, on any modification of the present exchange position, but I would like particularly to impress on American manufacturers the necessity of looking well to the efficiency of any establishments they may have erected for British manufacturers before approaching our continental neighbors, for the French buyer will invariably ask, "Well, enfin, how does it run under English conditions," and not only that but a few short hours will bring over the manufacturer himself to this country to find out how things really stand.

Yours faithfully,

DONALD ROBERTSON, B. Sc. Tech.,
Works Chemist, Messrs. John Lumb & Co., Ltd.,
Castleford, Yorkshire, England.

August 28, 1922.

Electrical Conductivity of Glass at High Temperatures

By R. S. McBRIDE*

The problem of conductivity measurement in a material like glass is a difficult one, for such material really acts as a very viscous liquid. Especially near the melting point, the material is partially electrolyzed while carrying the current and because of the high viscosity of the liquid, apparently an exaggerated polarization effect follows. The diffusion in viscous liquid is extremely slow so that the diffusion which normally eliminates polarization does not take place to any appreciable extent.

Preliminary search of the indexes of *Chemical Abstracts* indicates only three or four articles bearing upon this subject. The more important information is in the articles quoted below.

Several methods for the electrical conductivity measurement have been described in the literature but none of those described has apparently been very reliable. One method for work of this sort which has been thoroughly satisfactory on certain fused salts has not yet been published and because of certain patent considerations cannot yet be described. When it is possible to describe the apparatus and method referred to, it will then be possible to do that kind of work with much greater success in the future than in the past.

A few data on the conductivity of glass and porcelain and the variation of conductivity with temperature are given in the Smithsonian Physical Tables, 7th revised edition, page 332. However, most of the data apply only to low temperature; that is, below 300° C. One set of data does reach 800 or 1,000°, being that taken from Somerville, who published an article in the *Physical Review*, Volume 31, page 261, 1910. However, these data refer to the resistance of the material in a solid state only.

The three most important abstracts referred to above are quoted as follows:

C. A. 7, 1913, pp. 2150—"Electrical Conductivity of Glass and Quartz. Richard Ambronn. Göttingen. Physikalische Zeitschrift, 14, 112-8.—A. was unable to find a satisfactory non-polarizable electrode, so he had recourse to platinizing and used d. c. through the measuring instruments but a. c. (obtained by means of a small rotating commutator) through the sample. The material was in the form of plane-parallel disks, about 20 mm. diam. and 2-3 mm. thick; the 3 glasses investigated had the comp. 2 mols. SiO_2, 0.25 mol. CaO, with (a) 0.50, (b) 0.75, (c) 1.0 mols. Na_2O, resp. The relation between abs. temp. and the sp. resistance (W) of the glasses is given by the exponential formula $W = \alpha\epsilon\ \beta/T$; the values of 10^5 and of β for the 3 glasses are: (a) 1035.6, 9482; (b) 642.5, 8779; (c) 498.3, 8155. β is a linear function of the conc. of Na in the above glasses. The measurements with quartz crystals show that the resistance, unlike that of the glasses, varies with the frequency of the a. c. Expts. were undertaken with slices cut at various angles to the axis of the crystal but the results cannot be readily summarized, except that a more complicated exponential was required to express the relation of W. and T."

C. A. 7, 1913, pp. 3443—"Note on the Resistivities of Glass and Fused Silica at High Temperatures. Albert Campbell. National Physics Laboratory. Proceedings Physical Society London, 25, 336-7.—Measurements were made on tubes 30 cm. long, 1 to 4 cm. in diam., and of wall thicknesses 0.05 to 0.12 mm. The tubes were platinized inside and outside for a considerable part of their length. At each end there was an unplatinized gap, and a platinized ring beyond this, these rings being connected by guard wires. For measurements at high temps. the tubes were heated in an elec. furnace; the voltage ranged from 200 to 500 v. at ordinary temp. to 2 v. at the highest temp. Samples of mica were tested in the form of thin sheets. Some of the resistivities in megohms-cm. were: Fused silica at 15°; over 2×10^8; at 150°; over 2×10^8; at 230°, 2×10^7; at 250°, 2.5×10^6; at 700°, 30; at 800°, about 20. Glass (ordinary) at 18°, 5×10^5; at 145°, 100. Glass ("Gerate") at 18°, 3×10^6. Glass (Jena combustion) at 18°, over 2×10^8; at 150°, 1.8×10^7; at 750°, 0.01 to 0.04. Mica (0.026 mm. thick) at 18°, over 3×10^8; at 135°, over 3×10^8."

C. A. 13, 1919, pp. 1375—"Conductivity of soda-lime-silicate glasses. R. Ambronn. Physikalische Zeitschrift 19, 401-5 (1918); Annalen der Physik 58, 139-64.—Thirteen glasses containing SiO_2, soda (12-36% Na_2O) and lime (4-20% CaO) have been examd. The influence of temp. on the cond. is expressed by the equation: $L = L_0\epsilon^{-\beta/T}$, where L is the elec. cond. of the glass, T the abs. temp., and β and L_0 are consts. L_0 the cond. at abs. zero, is detd. by the expression $L_0 = M + uc + vk$, where c and k are the concns. of the Na_2O and CaO, resp. The cond. has been found to have positive values only when c is greater than 28 per cent or k greater than 28.5 per cent. It has been deduced that 11 per cent of the Ca and Na atoms jointly are fixed and take no part in carrying the current."

*National Research Council, Washington, D. C.

Glass Technology*

By GEORGE W. MOREY†

The war period preceding that under review was marked by extraordinary activities in the field of glass technology, and it is to be expected that the period of business depression through which we have been passing should show a diminution in activity. While such a diminution has taken place and while no such developments as that of pyrex glass or the remarkable upbuilding of the optical glass industry during the war are to be chronicled, still the development of the industry has been steady and the technologic advances important.

In the line of fundamental research probably the most outstanding contribution has been the comprehensive paper by Adams and Williamson on the annealing of glass, for which the authors were awarded the Longstreth Medal by the Franklin Institute of Philadelphia. Glass annealing is an ever-present problem in all branches of the industry, the solution of which has been in the past groped for in the dark. It had not been realized that "slow cooling" was not sufficient to ensure good annealing; to be sure, slow cooling is essential at a certain stage in the process, but most commercial installations succeed in cooling ware too rapidly in its critical stage, and draw out the cooling to unnecessary lengths when the necessity for control has passed. Adams and Williamson have given a striking illustration of the possibilities in carefully controlled annealing. As is well known, optical glass must satisfy particularly rigid specifications in the matter of strain, and the type of glass known as borosilicate crown is particularly difficult to anneal. Yet by precise furnace control, guided by the very definite rules which they have given, they were able to anneal a slab of borosilicate crown 2 cm. (0.8 in.) thick in 4 hrs. and 50 min. from the time the cold glass was placed in the cold furnace. Annealing problems as difficult as this are not common in practice; yet it is not unusual for days to be given to poorly anneal the more tractable plate glass of the same thickness. By the application of scientific methods superior annealing could be obtained in less time, thereby releasing equipment, increasing production, and decreasing cost. Adams and Williamson's paper is noteworthy in that it not only discusses the annealing of glass from the scientific viewpoint, but also gives explicit detailed instructions for the annealing of various types of glass in various thicknesses. A noteworthy instance of the successful application of these results is the 40-in. reflector disk manufactured in this country during the past year, an achievement described in the June issue of *The Journal of Industrial and Engineering Chemistry.*

The relation of the physical properties of glass to chemical constitution is of fundamental importance in glass technology, and several investigators have been active in this field. In this country the activity is chiefly shown in the number of composition patents that have been issued, including patents on a glass which, while opaque to visible radiation, transmits the infra-red, and also on a glass which, while opaque to the visible, transmits the ultraviolet. An industrial development of technical importance, especially in the application of automatic machines, is the conversion of the electric light bulb from a lead glass to a lime-magnesia glass which can be melted successfully in tanks. Attention should also be called to the work of Peddle, published in the *Journal of the Society of Glass Technology,* which is the most complete and extensive study of the relation between chemical composition and physical properties that has yet appeared. The work to date includes the soda-potash-lime, the soda-potash-lead, and the soda-potash-barium glasses. The physical properties determined are primarily those of interest to the optical glass manufacturer: refractive index, dispersion, comparative "fusibility," and resistance to weathering and to the action of reagents, these latter properties being of importance in all branches of the industry. The important factor of viscosity has not been determined in these extensive experiments, but that is a problem in itself, a problem the study of which is still awaiting the development of a satisfactory technic. Attention is being given this problem, however, both by the manufacturers themselves and by such institutions as the Department of Ceramics of the University of Illinois and the Bureau of Standards, and it is to be hoped that we will soon have not only methods but also data at our disposal. Much additional work is necessary in order to satisfactorily correlate physical properties with chemical constitution, and the subject appears the more difficult as, with the more accurate determination of physical properties, the futility of attempting to represent any property of a glass on a purely colligative basis becomes apparent.

Purely technical developments have followed the lines laid out in previous years. Unfortunately, there is still litigation over some of the important new processes, but final decision has been reached in the "cold bait" patents, of importance in several branches of the glass industry. A development of prime importance, which has been foreshadowed by years of experiment on the part of many firms, is the commercial success of the sheet glass drawing process, which has reached such a stage that 84-in. sheets can now be drawn, and two drawing machines operated from one tank. A striking development has been the rapid extension in the field of application of glass feeders, and the development of several new types, though the Hartford-Fairmount machine still appears to be in the lead. A 15-arm machine of the Owens type for bottle work has been developed. The field of application of automatic machinery has been further extended to bulbs, the manufacture of the latter by machine being now on a commercial basis. The semi-automatic machine has been successfully applied to tumblers and thermos-bottle liners. It appears probable that the next few years will see a still more widespread application of glass feeders and automatic machines, with resulting transformation of the glass industry "from a small scale, many unit skilled craftsman's constant personal triumph over miserably poor and inefficient equipment into an engineering enterprise of first magnitude."[1]

This review has so far confined itself to technical progress, but progress has been made along another line which may in the last analysis prove of more value to the industry as a whole than the more purely material achievements. During the period since the war, there has been developing a spirit of recognition not only of the value of scientific research and control, but also of the value of co-operation and an *esprit de corps,* which bids fair to sweep away the mists of trade secrecy that have in the past oppressed the glass industry. Two new trade journals have appeared, THE GLASS INDUSTRY and *The Glass Container.* The latter of these is the organ of the Glass Containers Association of America, itself an example of the new spirit in the glass industry. This association is not only supporting a journal, but has taken as active part, with the cooperation of the Bureau of Standards, in the standardization of glass containers, and in encouraging and supporting research. The phenomenal growth of the Glass Section of the American Ceramic Society, the only common meeting ground of glass chemists and technologists in this country, also shows that the men in the glass industry are awakening to a realization that the path to progress is one of respect and cooperation, not one of secrecy and distrust.

[1] Dowse and Meigh, *J. Soc. Glass Tech.,* 5 (1921), 152.

* Jl. Ind. and Eng. Chem., 1922, Vol. 14, No. 9 (Sept.), p. 823.

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Study of Electric Furnace Refractories

As it is hoped to develop refractories for electric furnaces, it is desirable to have a method and apparatus for measuring their conductivity at advanced temperatures, states the Federal Bureau of Mines. Moreover, data in regard to the conductivity of existing refractories at temperatures above 1400° C. are meager. It is proposed by the bureau to study the leakage factor through refractories. The method of attack has been worked out and the furnace designed, the material for which is arriving at the Bureau's ceramic experiment station at Columbus, Ohio.

Patents and Patent Law*

By AMASA M. HOLCOMBE†

There are four classes of inventions that may be patented, namely, arts, machines, manufactures and compositions of matter, and unless an invention is within one of these classes it cannot be patented. Machines, manufactures and compositions of matter are in the eye of the Patent Law just what these words signify in every-day life; but in "arts" are included only processes having to do with the use of the forces of nature to produce concrete physical results. Statements of principles and claims for the use of the forces of nature broadly without definite sequence or means of application are not patentable as inventions.

An invention may be "sole" or "joint"; that is it may be the result of conception and development by a single inventor or even by several persons working under the inventor's direction and developing his suggestions and ideas, in which case it is a sole invention; or it may be the joint product of two or more inventors working together and each contributing to the result independently of the suggestions of the other but in such a manner that the contributions are not segregable. If the invention is a joint product of independent minds, all the inventors must join in the application in order to secure a valid patent; and conversely if a sole invention, it cannot be made the subject of a joint application no matter how many assisted the inventor.

A patent may be reissued if it be found to be inoperative or invalid by reason of a defective or insufficient specification or too broad a claim, if the error has arisen by inadvertence, accident or mistake, and without any fraudulent or deceptive intention. The courts have established the general rule, however, that the claims cannot be broadened by reissue after two years from the date of the patent, and that a claim which has been presented and canceled or withdrawn in the original application cannot afterwards be secured by reissue.

There is more or less misunderstanding of the extent to which a patent may be relied on as authoritative permission for the patentee to use the invention described therein. To begin with, it is the claims rather than the description and drawings that measure the extent of the monopoly secured by the patent, and the subject matter set forth in the claims may embrace much that was not the invention of the patentee but was selected by him as the foundation upon which to improve. Obviously, the patent can convey no right to the use of such things as were not invented by that patentee, and hence it is important to know what has gone before in order to differentiate between what is old and what is novel in the patent. Furthermore, there may be other patents, usually of earlier date, containing generic claims broadly protecting features essential to the use of the improvement patented to the later inventor, and the grant of the later patent is not a bar to a suit for infringement of any dominating patent.

It must be remembered that the right to use the invention described in the patent specification does not flow from the grant but is the same right as that of any owner of property to use his own so long as his use does not conflict with the rights of the public as expressed in general laws and the individual rights of other property owners, for example, other patentees. The patent may be presumptive evidence of this right of ownership, and in case of doubt as to what is and what is not within the scope of other patents, the possession of a patent may be enough to enable its possessor to escape a charge of infringement.

The principal right arising upon the grant of the patent (as distinguished from the rights of ownership and use that the inventor acquires upon making the invention) is that of calling for the assistance of the courts in preventing unauthorized use of the invention by others. What this right is and how it can be exercised and enforced are determined partly by the patent specification and claims, and partly by the patent laws and the rules and decisions of the courts; but the comparative ease or difficulty of determining and enforcing a patentee's rights are dependent very largely upon the wording of the specification and claims, as in the case of deeds, contracts, wills and other legal instruments. Mr. Justice Brown, of the Supreme Court of the United States, speaking for the Court in Topliffe vs. Topliffe (145 U. S. 581), said: "The specification and claims of a patent, particularly if the invention be at all complicated, constitute one of the most difficult legal instruments to draw with accuracy." Hence the need for care and foresight in preparing the specification of an application for patent to distinguish between the essential aims and attributes of the invention and the non-essential characteristics of its immediate embodiment and surroundings.

In addition to the right to prevent others from using a patented invention patents have other valuable attributes. For example, they may be given a valuation based upon the actual cost of the purchase and development of the invention covered thereby prior to the date of issue of the patents, and their valuation, if properly shown on the books, will be accepted by state officials as a basis for issuing capital stock, and by federal officials for computing invested capital in making income tax and excess profit tax returns. It is interesting to note that the Treasury Decisions except capital stock paid for patents from the twenty per cent limitation upon the good-will and certain other intangibles fixed in the Act of 1917, but that they are expressly included by the Act of 1918, which fixes the total capital stock allowed to be based on such intangibles at 25 per cent.

Inventors should not be too precipitate in seeking to procure the actual grant of patents upon their applications, as frequently defects or omissions in the original description or claims do not become apparent until a device has gone into actual use, and if the application has not issued as a patent the defect may be corrected or omission supplied much more readily than by seeking a reissue after the patent has been granted. Furthermore, the pendency of the application in the Patent Office is to a considerable extent a safeguard against the grant of a dominating patent to someone else working in the same field during the development period of the invention. Until a device is actually placed on the market there is usually no need for patents to protect the invention, as hurtful competition rarely precedes the demonstration of the practical value of an invention by successful sales.

Manufacturers complain that the patent system is abused by crafty inventors and patentees who do nothing to advance the practical progress of the art but strive to set traps to prey upon those who are actively developing improvements and making things for use and sale. The rules of the Patent Office do not provide for access by the public to pending applications, and sometimes a patent will be kept pending in the Patent Office for several years before it is issued and made known to the public. In the meantime, a manufacturer may have established a good business based on the patented invention without knowing that it is patentable. Any search of the Patent Office records that he is permitted to make or have made for him will not disclose the fact that a patent is pending. His best protection against such a contingency is to file an application in his own behalf and thereby procure the Patent Office to make a so-called "interference" search to uncover any other applications having claims interfering with his own.

Manufacturers also complain that the Patent Office rules favor the so-called "paper" inventions or patents, applied for before the details have been sufficiently developed to make the practicability or even the operativeness of the invention assured, over the later filed application disclosing a fully tested operative and successful device. This complaint ignores the purpose of the Patent Law to hasten the disclosure of the invention to the public. The thing for the manufacturer to do is to file his application as soon as the inventive thought has shaped itself in his mind sufficiently to enable it to be sketched out on paper, and then later, if further study and the trial of experimental devices lead to changes or improvements, file a continuing application containing the additional matter.

* Abstracted from a paper read before the Buffalo section of the American Society of Mechanical Engineers, January 4, 1922.

† Counsellor at Law, with Emery, Booth, Janney and Varney, Washington, D. C.

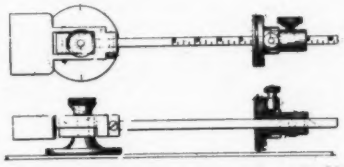
Recent Patents

NEW INVENTIONS DESIGNED TO IMPROVE GLASS AND THE MEANS OF PRODUCING IT

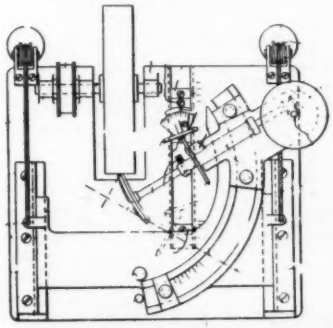
Copies of the Patent Specifications mentioned below may be obtained from the Commissioner of Patents, Washington, D. C. Price 10c. each.

Rotary-Glass Cutter. U. S. 1,421,921. July 4, 1922. Carl F. Doerr, of Yonkers, New York.

The invention relates to glazier's implements, and its object is to provide a new and improved rotary glass cutter arranged to enable the user to readily adjust the glass cutter for cutting glass disks of any desired diameter. One object is to prevent accidental shifting of the base on the glass during the cutting operation and to prevent the binding of the cutter bar. Another object is to counterbalance the cutter with a view to insure easy running of the revoluble cutter on the glass. Another is to permit of quickly replacing worn out or broken cutters by new ones and without requiring the aid of skilled workmen for making the change. Still another object is to permit of using the cutter on flat or convex surfaces and the cutting of smaller circular disks.

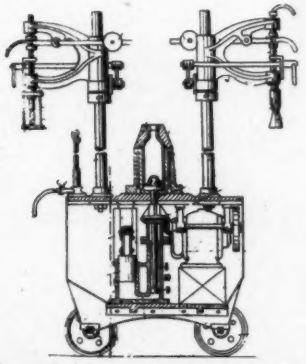


Machine for Grinding Beveled Rim Surfaces on Spectacle Glasses. U. S. 1,422,055. July 4, 1922. Otto Henker, of Jena, Germany, assignor to the firm of Carl Zeiss, of Jena, Germany.



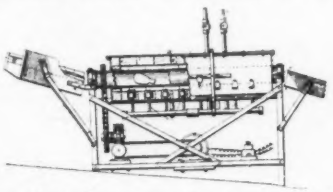
The present invention relates to a machine for grinding beveled rim surfaces on spectacle-glasses, in which the grinding of a rim surface is limited by a cam which is rotatable about an axis parallel to the axis of rotation of the spectacle-glass and by a stop coacting with the said cam, and more particularly to a machine of the above kind, which is adapted for grinding rim surfaces on spectacle-glasses, the sides of which are dissimilar and which are not circular.

Production of Bottles or Other Vessels and Apparatus Therefor. U. S. 1,425,124. August 8, 1922. Maurice Mathy, of Liege, Belgium.



The present invention relates to a machine for manufacturing bottles or other vessels by blowing, this machine being essentially differentiated from known machines of the kind by the fact that the bottom of the mold rises inside the body of the mold in such a way as to raise the upper level of the blank to the upper level of the bottle or other vessel to be obtained. When the blank occupies this position a tool carried by a bracket is inserted into the blank so as to form the hole for the upper part of the neck. This tool is withdrawn and then swung away from the mold by rotating the bracket that carries it, after which a compressed-air supply device terminating in a suitable nozzle and carried by another bracket, is brought over the mold and enables the blowing to be effected. The apparatus is completed by the provision of means enabling the bottle or other vessel to be rotated inside the mold.

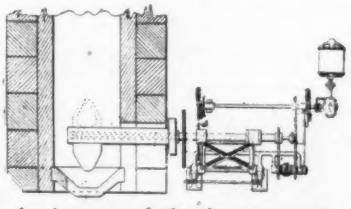
Rotating Lehr and Method of Operating the Same. U. S. 1,416,595. May 16, 1922. James Bailey, of Corning, New York, assignor to Corning Glass Works, of Corning, N. Y.



This invention has for its purpose to provide a novel method of feeding articles during the heat treatment thereof and a novel apparatus whereby such a method may be carried out, to the end that all parts of the surface of such article shall be uniformly exposed to identical heat conditions during the period in question.

This invention in so far as it relates to the apparatus employed comprises a rotary chamber, preferably circular in cross-section (although this shape may be departed from to some extent), and means for heating the interior thereof, preferably, but not necessarily, by conduction through the walls of the chamber.

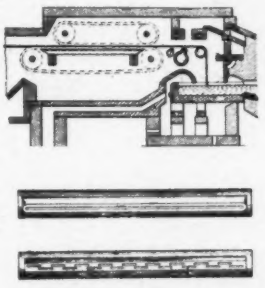
Obtaining Glass. U. S. 1,424,184. August 1, 1922. Jesse M. Said, of Corning, New York, assignor to Corning Glass Works, of Corning, N. Y.



Heretofore in automatically delivering molten glass from pots or furnaces, it has usually been the custom to discharge the glass into receptacles such as molds or the like, either through an opening in the bottom of the furnace, or by means of an intermittently oscillated paddle that would discharge the glass over a lip formed in a forehearth attached to the working end of the furnace.

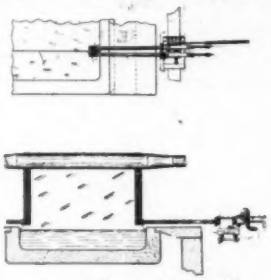
In the present case, charges or gobs of molten glass are scooped up from a gathering pool, and then carried outwardly beyond the edge of the pool, where the ladle is inverted to permit the molten glass to fall into a suitable receptacle, such as a mold.

Manufacture of Sheet Glass. U. S. 1,424,155. August 1, 1922. Henry F. Clark, of Belle Vernon, Pennsylvania, assignor to Window Glass Machine Company, of Pittsburgh, Pa.



In the drawing of sheet glass one of the difficulties which has been encountered and which has made it difficult to produce commercial glass of the higher grades, in quantities, is the "pimpled" or roll-marked character of the surface of the glass when it contacts with the roll or rolls used in the drawing apparatus. This invention is designed to overcome this difficulty. It provides means for heating and softening the under surface of the glass sheet immediately after such surface passes out of contact with the bending roll, and at a time when the temperature of the sheet is below that of plasticity. The action of such means is substantially a "fire-flashing" which is sufficient to fuse, or partially fuse, the immediate surface of the sheet to an extent which will obliterate the objectionable pimpling of such surface.

Apparatus for Drawing Sheet Glass. U. S. 1,425,225. August 8, 1922. James Whittemore, of Detroit, Michigan, assignor to the Libbey-Owens Sheet Glass Company, of Toledo, O.



In the Colburn patents, a sheet of glass is drawn vertically from a bath of molten glass, and is then bent laterally over a cooled bending roll and carried away horizontally through a suitable drawing mechanism and lehr. At each edge of the sheet, adjacent the drawing point, is a pair of cooled edge rolls, between which the edge portion of the sheet is drawn to form the same. These edge rollers are driven at a peripheral speed less than the linear speed at which the sheet is being drawn, so that a down pull or drag is made upon the edge portions of the sheet to stretch them tight between the source and the bending roll. This dragging action, together with the cooling effect of the water-cooled rollers, serves to overcome the natural tendency of the sheet to narrow as it is drawn upward. The inventor claims that he discovered that it is unnecessary, and sometimes undesirable to drive these rollers, but that on the contrary they may be used as idlers and driven from the sheet itself as it is drawn therebetween. The friction of the rollers and cooperating parts, furnishes the necessary drag on the sheet edges, and this friction may be supplemented and controlled by an adjustable friction brake on one or both of the roller shafts. The inventor also contemplates using an improved form of edge roll, having a series of peripheral grooves to engage the glass sheet and further counteract the tendency to narrow.

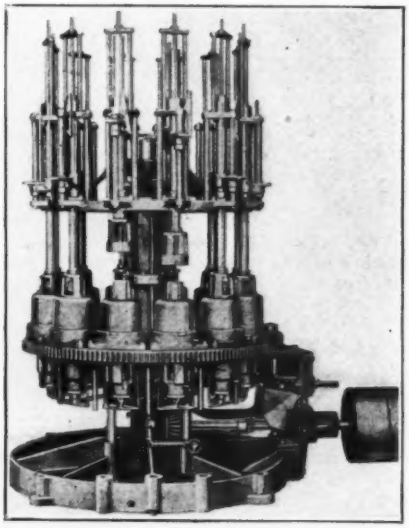
Glass Factory Equipment and Supplies

THE GLASS INDUSTRY will be glad to publish descriptions of new and useful devices, machinery and supplies of interest to the glass manufacturing trade. Most of the information printed in this department comes direct from the manufacturers of the products described.

New Automatic Tumbler Grinding Machine

A new "Edward Miller" 12-spindle automatic tumbler grinding machine, designed especially for use on thin blown tumblers and stemware has been brought out by the Miller Machine and Mold Works, 704 Ann street, Columbus, O., and is illustrated here.

The principal features of the machines as described by the manufacturers include automatic operation, simplicity of design, high grade annular and thrust bearings, with Alemite positive greasing system, special gears and pinions not affected



TWELVE-SPINDLE AUTOMATIC GRINDER

by oil or dampness, automatic kick-out and inside tumbler washer, which also supplies water for grinding.

It is operated by one girl whose duty is to put on tumblers and take-off after the automatic kick-out kicks the tumbler out of the chuck onto the spindle in the same position as for grinding. The makers state that this machine will grind thin blown tumblers at the rate of 28 to 38 per minute, or from 140 to 190 dozen per hour. The machine has twelve grinding spindles and three speeds, namely: 28, 33 and 38 per minute. It is a single belt driven machine direct from a line shaft and requires 5 h.p. for its operation. It requires 4 x 6 feet of floor space, is 6 feet high and weighs 2,500 pounds.

The Corrugated Fiber Shipping Box

Nearly everyone is familiar with the appearance of the corrugated fiber shipping boxes now so generally used for the packing of glassware and goods to be transported by freight, express and parcel post, but, although the process of their manufacture is not complicated, many have been led into conjecture as to the method used to produce and fabricate the cellular material of which they are composed.

The term used by the railroads to designate containers made of this material is somewhat misleading. In the Railroad Classification they are called Corrugated Strawboard boxes, yet only about one-third of the raw material, of which corrugated fiberboard is made, comes from straw, the other two-thirds being almost entirely composed of wood fiber.

The Hinde & Dauch Paper Company, of Sandusky, Ohio, is a pioneer in the manufacture and fabrication of corrugated fiberboard and from an examination into the manufacturing processes of that company, we are able to give a pretty clear description of the manner in which this useful box material is produced and used.

The average corrugated fiber shipping box required by the railroads to test up to 175 lbs. and 200 lbs. puncture resistance to the square inch respectively according to the requirements of contents, is made of what is called .009 strawboard faced with pulp board, either sixteen-thousandths or eighteen-thousandths of an inch thick, as the case may be. This corrugated sheet of strawboard forms the stiffening or backbone of the finished board. The Hinde & Dauch Paper Company pays special attention to the quality of its strawboard for corrugating purposes all of its boards and papers being made in its own mills, where it is able to see that as much material as can be compressed in the rolls to .009 thickness is put into this stabilizing and stiffening sheet, for, while a softer sheet tests higher because it collapses under the pressure of the testing gauge and resists puncture with the combined strength of both facing sheets, it is manifest that in actual service the stiffer and stauncher this corrugated sheet is made, the firmer and more reliable will be the container into which it is built.

From the paper mill this strawboard goes to the box factory where it is run between hot grooved rolls which press it into corrugated form and, before it leaves the corrugating machine, it is glued mechanically to the stiff facing sheet which forms one side of the finished board.

Next, the material goes to the double facing machines which attach the opposite facing sheet and cut the board into suitable lengths. The material used to attach these "liners," or facing sheets, is silicate of soda, an odorless mineral compound of great adhesiveness for which rats and mice have

no liking, as they find it both unpalatable and indigestible.

From the double-facers, the sheets go into storage for seasoning under pressure, to prevent any warping of the board. Then, as required, they are taken to the box machines, which cut out, score and slot the box blanks, and leave them ready for folding and taping.

Strips of strong adhesive linen tape of exact length and proper width are now attached by hand so as to join the two fold ends of the box blank, and thus to close the open corner of the completed box. No machine thus far designed has equaled the human hand for this work of taping, upon the thoroughness of which depends the reliability of the entire package.

The folded and taped boxes are kept piled on trucks, under weight, until the adhesive of the tape has thoroughly set. They then go to the printing presses which imprint the purchaser's trade mark or label in either one or two selected colors on any two adjacent sides, with a single operation.

When the printing is to be omitted, the taped boxes go direct to the baling room where the printed boxes are now taken, as soon as the ink on them is sufficiently dry. Here the boxes are counted out into bundles of standard quantity, and each bundle is carefully wrapped in heavy paper, tied securely with strong cord and stenciled to show the shipping directions and description of contents. The boxes are now ready to be taken to the shipping room, the loading platform and the railroad car.

Since the requirements of hardly any two shippers are identical there must be more or less machine adjustment with attendant waste of partly finished goods at each stage of the process we have described, and therefore, a rigid inspection after each manufacturing operation is essential to the maintenance of standard quality.

Most shipping boxes for glass are provided with corrugated partitions, pads and liners. The last named are scored sheets which fit inside the box and reinforce its four side walls. Pads similarly cushion and strengthen the top and bottom and are also inserted between tiers. Partitions are half slotted and interlocked upright sheets which cross each other and form cushioned cells for the reception of the individual glass containers.

All these accessories are usually made of double-faced board with the special qualities of softness and resilience rather than those of firmness and tensile strength. The sheets are cut to size by machinery which, at the same time scores the liners for bending at the corners, and the partition pieces are then slotted half way across by sawing or die cutting according to requirement. They are now ready to be assembled by hand, collapsed into compact form and bundled for shipment to the user.

These mechanical operations of corrugated fiber shipping-box production do not by any means complete the service of the reliable box maker to his clients. Before a step is taken or a wheel turned the shipper's packing needs must be accurately ascertained and, very often, the material and construction, the exact dimensions and the interior equipment required can be determined only by actual experiment.

Then too, boxes are required when goods are to be shipped and not after they have been delivered. It is therefore incumbent on the box-maker to keep up his supply stocks and to be ready at all times to manufacture and ship, with all due dispatch, any of the innumerable sorts and sizes that may be required.

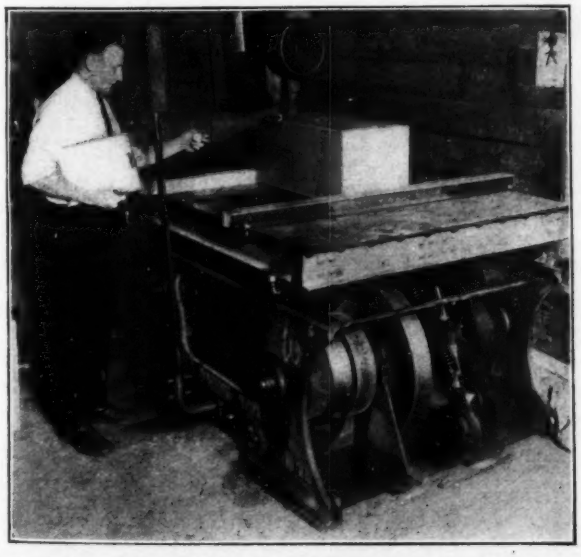
Packing and sealing methods are also of prime importance to the user of corrugated boxes and the conscientious box manufacturer will always be ready to help with suggestion or demonstration. In fine the trustworthy manufacturer of corrugated fiber shipping boxes sells a complete and constant service and not a mere commodity.

The Glass World and What It Is Doing

News of the Industry Briefly Told

A New Box Testing Machine

A shaking motion like the jerk and sway of travel in a freight car is given to boxes placed on this new testing machine designed by engineers at the Forest Products Laboratory, Madison, Wisconsin. The tendency of nailed edges of wooden boxes to weave and skew is the special characteristic to be determined by this test. The table to which the box is attached moves backward and forward through a distance of several inches on wheels rolling on rails at either side and the shaking effect produced may be varied through the use of the several speeds of which the machine is capable.



BOX TESTER DEVELOPED AT FOREST PRODUCTS LABORATORY

The Chemical Exposition at New York

The eighth National Exposition of Chemical Industries held at New York during the week of September 11, drew a large attendance from all sections of the country. Several glass manufacturers exhibited their products. The Bausch & Lomb Optical Company, Rochester, N. Y., had an interesting display of optical glass and other specialties. The Corning Glass Works, Corning, N. Y., had an attractive exhibit of pyrex and other glassware. The Whitall-Tatum Company, Millville, N. J., exhibited their extensive line of prescription and proprietary bottles and other containers.

A number of manufacturers of equipment and supplies for glass factories were on hand, including several pyrometer manufacturers, as follows: Wilson-Maeulen Company, New York; Brown Instrument Company, Philadelphia, Pa.; Charles Engelhard, Inc., New York; Leeds & Northrup Company, Philadelphia, Pa.; Thwing Instrument Company, Philadelphia, Pa.; and Bristol Company, Waterbury, Conn. Other products exhibited were: insulating brick and Hytempite cement, Quigley Furnace Specialties Company, New York; insulating brick, Armstrong Cork & Insulation Company, Pittsburgh, Pa., and Celite Products Company, Chicago, Ill.; electric equipment, General Electric Company, Schenectady, N. Y., and Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.; gas and air burners, Surface Combustion Company, New York; gas regulating equipment, Mono Corporation, New York; soda ash and other chemicals, Mathieson Alkali Works, New York; abrasives, Carborundum Company, Ni-

agara Falls, N. Y., and Norton Company, Worcester, Mass.; filtration plants, Permutit Company, New York, and New York Continental Jewell Filtration Company, Nutley, N. J.; Kryolith and other products, Pennsylvania Salt Manufacturing Company, Philadelphia, Pa., fans and blowers, B. F. Sturtevant Company, Hyde Park, Mass.

The National Lime Association, Washington, D. C., had a booth, and Dr. M. E. Holmes, secretary of the association was on hand to meet visitors and discuss their lime problems.

The meeting of the American Ceramic Society on Ceramic Day, September 15, was well attended and a number of papers of interest to the glass section were presented, including the following: "High Temperature Cements," by W. H. Gaylord, Jr., of Quigley Furnace Specialties Company; "Application of Magnetic Separator in Ceramic Industries," by E. S. Hirschberg, of Dings Magnetic Separator Company; "Gas Producers for Glass Works," by C. B. Chapman, Chapman Engineering Company; "Discussion of the Reasons for the Varieties of Shapes and Sizes," by Judge I. G. Jennings, of the Glass Container Association; and "Standardization of Fireclays and Refractories," by Ross C. Purdy, secretary of the American Ceramic Society.

A colloquium on feldspar brought out interesting suggestions for standardizing feldspar specifications in accordance with the requirements of the principal consuming industries. W. H. Landers said that glass makers can use profitably feldspar which has passed through 40 mesh but remained on 100, and contains not over 10 per cent finer than 100 mesh.

Wage Agreement Reached

Formal announcement of the settlement of the wage question was made on Monday, September 18, by J. R. Johnston, Jr., secretary-treasurer of the National Association of Window Glass Manufacturers. On the previous Saturday it was agreed between the manufacturers' and workers' committees that wages should be the same as last year, plus 5 per cent; single strength gatherers will receive 80 per cent of gross wages; all limits have been removed except that the blowers will not be permitted to make more than nine rollers per hour. Factories were authorized to go into operation from September 25 to October 9.

The first period plants may operate sixteen weeks between September 25 and January 27; the second period plants may operate eighteen weeks from January 29 to June 11. The plants which will operate during the first period are:

		Pots
Alliance Window Glass Co.	Salem, W. Va.	36
Baker Brothers Glass Co.	Okmulgee, Okla.	42
Blackford Window Glass Co.	Vincennes, Ind.	30
Buckeye Window Glass Co.	Columbus, Ohio	27
Camp Glass Company	Huntington, W. Va.	60
Doddridge Window Glass Co.	West Union, W. Va.	24
Dunkirk Window Glass Co.	S. Charleston, W. Va.	39
Elk Run Window Glass Co.	Punxsutawney, Pa.	24
Federated Window Glass Co.	Point Marion, Pa.	36
Fredonia Window Glass Co.	Fredonia, Kans.	48
Harding Glass Co., No. 2	Fort Smith, Ark.	60
Hermosa Glass Co.	Hermosa Beach, Calif.	36
Illinois Window Glass Co.	Danville, Ill.	30
Independent Glass Company	Sistersville, W. Va.	24
Jeannette Window Glass Co.	Point Marion, Pa.	27
Lafayette Window Glass Co.	Clarksburg, W. Va.	36
LeFlore Window Glass Co.	Poteau, Okla.	48
National Sash & Door Co.	Independence, Kans.	30
Norwood Window Glass Co.	Clarksburg, W. Va.	42
Patterson Glass Co.	Cameron, W. Va.	24
Premier Window Glass Co.	Pennsboro, W. Va.	42
Reliance Window Glass Co.	DuBois, Pa.	30
Royal Glass Company	Grafton, W. Va.	24
Salem Co-operative Glass Co.	Salem, W. Va.	24
Sunflower Glass Co.	Sapulpa, Okla.	30
Torrance Glass Co.	Torrance, Calif.	36
Twin City Glass Co.	Texarkana, Tex.	36
Utica Glass Company	Utica, Ohio	48
Wichita Falls Glass Co.	Wichita Falls, Tex.	36
Wilcox Glass Co.	Wilcox, Pa.	30
		1059

Miscellaneous Items

Window Glass Manufacturers' Hearing.—The date for the trial of the Federal Government case against various window glass manufacturers for "restraint of trade" will be set at a hearing on October 9, in New York.

Glass lehrs constructed with "carbofrax," a refractory material made by the Carborundum Company, Perth Amboy, N. J., are reported to show in service considerable economy in fuel consumption, due to the extremely high heat conductivity of carbofrax as compared with fire clay.

Technical Note No. 172, Forest Products Laboratory, issued from Madison, Wis., contains notes on "How to Obtain Rigidity in Crate Construction," "Relative Durability of Native Woods," "Hard Wood and Soft Wood Drying Schedules," "Advantages of Ready-Cut Dimension Stock," and other subjects.

A competitor of the glass carboy has appeared on the market in the form of a rubber-lined barrel made by the Cleveland Cooperage Company, Cleveland, O. A large saving in first cost and freight charges is claimed as well as less depreciation and no breakage.

Over 52 Million Bulbs. The Wellsboro, Pa., branch of the Corning Glass Works from September 6, 1921, to September 2, 1922, manufactured and shipped 52,001,926 electric light bulbs, averaging more than 1,000,000 per week, which is said to surpass any record for lime glass and tank production in the same period of time. The plant closed on September 2 for the annual four weeks' vacation in order to make repairs to tanks, etc.

The 1923 Lighting Fixture Market of the National Council Lighting Fixture Manufacturers, the Lighting Fixture Dealers Society and the Illuminating Glassware Guild is to be held at one of the leading hotels in Cleveland, during the week of January 15, 1923. Secretary Chas. F. Hofrichter announces that no appeal is to be made to arouse local public interest as heretofore. The National Council will not be held during the market, the date for their annual convention being set for next summer. However, a keen interest will be shown by the manufacturers in the Dealers' Convention sessions and no doubt they will participate to some extent in the discussions.

Belgian Glass Situation Improving.—The window glass situation, according to a report issued by the Department of Commerce, is greatly improved, with twenty furnaces now producing, the largest number operating since the armistice. Prices are showing an upward tendency. Chinese orders are reported as increasing, and it is estimated that 2,000 cases per month are now being shipped to Java. The Val Saint Lambert Company is now operating seven furnaces, but the demand for crystal is still deficient, and unemployment is marked among glass cutters. Plate and bottle glass plants are now fully occupied, the latter operating at 75 per cent of capacity. As a result of the activity in small plants in all branches of the industry, wage difficulties have arisen.

Personal News

Dr. R. R. Shively (Ph.D., University of Pittsburgh) specialist in glass technology, for the past four years incumbent of the Monongah Glass Company's Industrial Fellowship in the Mellon Institute of Industrial Research, and chemical engineer for the company in its plant at Fairmont, W. Va., has become associated with the Drakenfeld Company, New York, as chief technologist. In this capacity Dr. Shively will be technical advisor to the officers of the organization. Dr. Shively spent the period of 1905 to 1908 as assistant in the department of chemistry at Oklahoma State College. From 1908 to 1911 he was located at the Bureau of Chemistry, Department of Agriculture, Washington, D. C. From 1911 until September 1st of the present year, he has served continuously as an Industrial Fellow at the Mellon Institute. During the latter period, he has specialized in glass and glass

making materials. In the meantime, Dr. Shively has served in consulting capacity for a number of different glass manufacturers and has done considerable research in the development of various types of glasses. During his association with the Monongah Glass Company, he has had charge of the operation of the tanks, producers and the making of glass. He has specialized particularly in the use of selenium as a decolorizer in flint glass. For the present Dr. Shively will continue to reside in Fairmont.

O. P. Cooke, at one time an assistant superintendent for the Hazel-Atlas Glass Company and later connected with the Jefferson Glass Company, Toronto, Ont., and with the Hartford-Fairmont Company, Hartford, Conn., has been appointed superintendent of the Mound City Glass Company, Lumberport, W. Va.

Recent Deaths

Edward B. Raymond, of Sewickley, Pa., vice-president and chairman of the manufacturing department of the Pittsburgh Plate Glass Company, dropped dead in his office in the Frick Building, Pittsburgh, Pa., on September 8. Mr. Raymond was 53 years of age, a graduate of Massachusetts Institute of Technology and before becoming connected with the Pittsburgh Plate Glass Company in 1910, was connected with the General Electric Company at Schenectady, N. Y.

Verified News of Trade Activities

The Combustion Utilities Corporation, engineers and erectors of industrial gas plants and furnaces, has moved its New York office from 60 Wall street to 24 State street.

The Ruth Glass Company, Conshohoken, Pa., is making repairs to its tube mill. The building was partly destroyed by fire during the war and the plant has been idle since that time. The company expects to resume operations in the near future.

Efforts to float a bond issue of $200,000, the proceeds to be devoted to acquiring manufacturing rights to the Fourcault process of drawing sheet glass are being made, it is reported, by interests connected with the Brookville Glass & Tile Company, Brookville, Pa.

The Wichita Falls Window Glass Company, Wichita Falls, Texas, will resume operations during the early part of October. The company has changed over its plant from the automatic machine method of blowing, which was installed about five years ago, to the original hand-blowing method.

The **Altoona Plate Glass & Beveling Company,** 912 Green avenue, Altoona, Pa., dealers in all kinds of glass, mirrors, etc., has purchased a building at 725 Green avenue which it will occupy as soon as the two-story addition which is being erected is completed. The addition is estimated to cost about $7,000.

The **West Virginia Glass Manufacturing Company,** Huntington, W. Va., has let contracts for additional equipment which they state will provide for a 30 per cent increase in next year's output. The new equipment will consist of machines for the manufacture of Mason jars and caps for same. The company recently introduced to the market a square-shaped jar with a glass top.

The General Refractories Company, Pittsburgh, Pa., has arranged for a bond issue of $4,000,000, the proceeds to be used in part for perfecting a merger of different refractory interests. It is reported that the company will take over the General Refractories Company of West Virginia, as well as the Standard Refractories of Clayburg, Pa., the latter acquisition involving one and one-half million dollars.

The Republic Glass Company, Monroe, Mich., is constructing a new one-story plant, about 200 by 400 feet, and erecting three modern furnaces which will enable them to furnish all standard colors of glass. The company will specialize in automobile and railway lenses, stop and tail lights, sky and sidewalk lights. Manuel Llera, is president; William N Mathews, vice-president, and J. Harry Williams, secretary and treasurer.

The Syracuse Glass Company, Syracuse, N. Y., is erecting a three-story addition to its present warehouse, which will double its present warehouse capacity. The first floor will be used for handling plate and rough glass and a modern beveling plant will be installed on the third floor. The present warehouse, which is also being remodeled, will be used exclusively for window glass.

The C. O. Northwood & Son Glass Corporation, Clyde, N. Y., has purchased the plant of the Clyde Glass Works and is making improvements and alterations. The new company will manufacture pressed table ware and illuminating goods as well as Kalana art etching on potash lead glass. The officers of the new company are: C. O. Northwood, president; H. Tappin, vice-president; A. N. Northwood, treasurer, and W. G. Edmonds, secretary.

The Atlanta Glass Manufacturing Company, Atlanta, Ga., has been incorporated with a capital of $500,000, to manufacture bottles and other glass products. The company has plans under way for the erection of a local plant. F. J. Cooledge, Jr., president of F. J. Cooledge & Sons, Atlanta, jobbers of glass and makers of paints and varnishes, is resigning that office to become president of the new glass company and devote all his time to it.

W. J. Miller, Swissvale, Pa., reports that repeat orders have been received from the Jeannette Glass Company, Jeannette, Pa., for two additional model AA high power table ware machines, which will be utilized for fabricating deck lights, vault lights, and a miscellaneous line of other pressed table ware. Two additional Miller model PC electrically and air operated machines of the latest type, were shipped to the Atlantic Bottle Company, Tarentum, Pa., for installation in their new factory. A battery of four of these machines will be used for manufacturing milks and tobacco jars, etc. A semi-automatic Miller machine was recently installed at Factory F of the United States Glass Co. This unit is being utilized for the manufacture of pressed door knobs, etc.

Stock Quotations

(Reported by Moore, Leonard & Lynch, Frick Building, Pittsburgh, Pa.)

PITTSBURGH STOCK EXCHANGE, September 22, 1922.

	Bid	Asked	Last
American Window Glass Machine, com..	79¾	80	80
American Window Glass Machine, pfd..	90	92	92
American Window Glass Preferred.....	103½	..	104
Pittsburgh Plate Glass.....	..	175	172
U. S. Glass.....	..	45	50½

The market for the past month has developed certain signs of weakness. A quiet tone has prevailed and while operations of the various companies are running at a satisfactory rate, no announcements, having value from a speculative standpoint, have been made.

WHEELING STOCK EXCHANGE, September 22, 1922.

	Bid	Asked	Last
Hazel Atlas	162	163	163
Imperial Glass	86	100	86
Fostoria Glass	116	...	116
Central Glass	90	100	100

The various glass issues on the Wheeling Stock Exchange exhibited a quiet tone during the last thirty days. The only issue showing any market activity was Hazel Atlas and it is reported that this Company is running at a rate that would indicate that the current year would prove to be the largest year in the Company's history. Hazel Atlas declared a $2.00 dividend payable October 2nd, to stock of record September 25. This Company recently announced an increase in wages approximating 20%. With the exception of Hazel Atlas, the group of stocks was characterized by inactivity and the slight amount of trading kept the price range within narrow margins.

TOLEDO STOCK EXCHANGE, September 22, 1922.

	Bid	Asked	Last
Owens Bottle Machine, common.....	39	...	39¾
Owens Bottle, preferred.....	104½	...	105
Libbey-Owens Sheet Glass, common....	130	135	134
Libbey-Owens Sheet Glass, preferred....	104	105	...

Inquiries Received

For further information address THE GLASS INDUSTRY.

88. Please give us the names of manufacturers and jobbers of both maized wire and polished wire glass.

89. Kindly inform us where we can obtain glass paper weights.

90.—Would you kindly give us the names of firms that handle glass crushing and pulverizing machines? We are in the market for a machine that will grind glass to a fineness of 60 mesh.

Current Prices of Glass-Making Materials

From quotations furnished by various manufacturers and dealers

September 25, 1922

	Carlots	Less Carlots
Aluminum hydrate ($Al(OH)_3$)..lb.	.05½	.06
Aluminum oxide (Al_2O_3).....lb.	..	..
Antimony oxide (Sb_2O_3).....lb.	.06½-.08	.08
Arsenic trioxide (dense white), 99% (As_2O_3).....lb.	.09	..
Barium carbonate ($BaCO_3$).....ton	61.00	71.00
Barium hydrate ($Ba(OH)_2$)....lb.	.05½	..
Bone ash .....lb.	.05½	..
Borax ($Na_2B_4O_7 10H_2O$) .....lb.	.05½-.06	..
Borax, fused, any mesh ($Na_2B_4O_7$) .....lb.	.19	.20
Boric acid, fused (B_2O_3).....lb.	.35	.35
Cadmium Sulphide, red (CdS)..lb.	..	1.60
Cadmium Sulphide, orange.....lb.	..	1.80
Cadmium Sulphide, yellow (CdS) .....lb.	..	1.90
Chrome oxide .....lb.	.35	.36
Cobalt oxide, in bbls. (Co_3O_4)...lb.	..	2.10
Cobalt oxide, in 10 lb. tins (Co_3O_4) .....lb	..	2.20
Copper oxide, red.....lb.	.14½	.17-20
Copper oxide, black (CuO).....lb.	..	.26
Copper oxide, black prep'd (CuO) .....lb.	..	.30
Cryolite (Na_3AlF_6) .....lb.	..	00½
Feldspar, 100 mesh.....ton	15.00	..
Fluorspar, powdered white, 95% (CaF_2) .....ton	35.00	..
Fluorspar, powdered white, 90% (CaF_2) .....ton	33.00	38.00
Hydrofluoric acid (HF) 60%..lb.	.13	..
Kaolin .....ton	17.00	25.00
Lead oxide (red lead) (Pb_3O_4)..lb.	.09½	.09¾
Litharge (PbO) .....lb.	.09	.09¼
Lime—		
Hydrated (in 50 lb. paper sacks) ($Ca(OH)_2$) .....ton	10.50	..
Burnt, ground, in bulk (CaO).ton	7.25	..
Burnt, ground, in paper sacks.ton	9.25	..
Burnt, ground in 280 lb. bbls. per bbl.	2.00	2.05
Manganese 85% (MnO_2).....lb.	.05	.05-.06½
Nickel oxide, black (Ni_2O_3) for nickel content .....lb.	..	.50
Nickel monoxide, green (NiO) for nickel content.....lb.	..	.50
Potassium carbonate—		
Calcined 90% (K_2CO_3).....lb.	.06¼-06½	..
Hydrated 90% (KOH) .....lb.	.06½	.08
Potassium nitrate (KNO_3) (gran.) .....lb.	.06½-.08	.06¾-.10¼
Powdered blue .....lb.	..	.24-.26
Powdered blue (std. formula)..lb.	..	.38
Salt cake, glassmakers, f. o. b. works (Na_2SO_4) .....ton	21.00	30.00-35.00
Selenium (Se) .....lb.	..	1.95-2.25
Soda ash, 58% dense, 48% basis Bulk (Na_2CO_3) .....100 lb.	1.22½	..
Bulk, on contract (Na_2CO_3) 100 lb.	1.17½	..
Sodium nitrate, refined ($NaNO_3$).lb.	.04½-.06	.04¾-.06¼
Sodium selenite (Na_2SeO_3).....lb.	..	2.35-3.00
Sodium Fluosilicate (Na_2SiF_6)...lb.	.08	..
Sulphur (S) (flowers)—in bbls. per 100 lb.	3.25	3.55-3.80
Sulphur (flowers) Bags per 100 lb.	3.00	3.30-3.55
Sulphur (S) (flour, heavy), in bbls. per 100 lb.	2.50	2.80-3.05
Uranium oxide—100 lb. lots (UO_3) .....lb.	..	2.25
Zinc oxide (ZnO) .....lb.	.07	.08

Monthly Summary of United States Foreign Commerce in Glass

Corrected to September 5, 1922

IMPORTS

	July 1921 Quantity	July 1921 Value	July 1922 Quantity	July 1922 Value	Seven Months Ending July 1921 Quantity	Seven Months Ending July 1921 Value	Seven Months Ending July 1922 Quantity	Seven Months Ending July 1922 Value
Glass and glassware:								
Bottles, vials, carboys, etc., plain, empty or filled lbs. .....dut.	896,125	$41,723	659,881	$23,845	4,043,443	$187,609	4,305,078	$158,319
Bottles, decanters and other glassware, cut or ornamented .....dut.	.....	152,151	.....	183,326	.....	823,374	.....	1,155,086
Optical instruments, including lenses and spectacles .....dut.	.....	97,598	.....	121,838	.....	627,532	.....	715,170
Sheet and plate glass—								
Cylinder, crown and common window glass, unpolished .....lbs. dut.	3,789,137	186,196	5,704,615	265,665	30,513,574	1,753,366	34,982,218	1,789,874
Plate glass, cast, polished, unsilvered, sq. ft. dut.	150,788	95,864	730,689	334,742	1,537,269	1,188,040	3,988,007	1,784,676
Plates or disks, rough cut, for optical purposes .....lbs. free	16,085	24,189	150,428	14,432	548,201	488,634	232,366	76,979
All other .....dut.	.....	286,939	.....	243,924	.....	1,453,695	.....	1,738,455
Total	.....	$884,660	.....	$1,187,772	.....	$6,522,250	.....	$7,418,559

EXPORTS

Glass and glass products (total).....	.....	$801,224	.....	$638,251	.....	$10,824,884	.....	$4,951,595
Plate and window glass—								
Window glass, common, box, 50 sq. ft.....	2,391	15,677	1,675	9,027	51,373	410,748	18,288	100,023
Plate glass, unsilvered, sq. ft.....	145,782	77,045	119,273	57,806	1,557,659	990,406	1,859,096	795,165
Wire glass, sq. ft.....	.....	.....	26,940	7,255	.....	.....	160,079	41,099
Other window and plate glass, n. e. s.....lbs.	.....	.....	72,542	10,691	.....	.....	1,029,585	121,967
Glass containers (bottles, vials and jars).....lbs.	.....	283,183	4,101,000	213,005	.....	3,482,206	22,169,549	1,249,320
Table glassware, plain.....lbs.	.....	.....	1,168,901	119,738	.....	.....	5,669,655	672,273
Table and other glassware, cut or engraved....lbs.	.....	14,336	39,233	14,297	.....	129,929	231,476	87,129
Glassware for lighting—								
Lamp chimneys and lantern globes.....lbs.	.....	.....	116,167	22,657	.....	.....	820,660	172,375
Globes and shades for lighting fixtures.....lbs.	.....	.....	101,734	28,675	.....	.....	837,302	242,518
Lamps and other illuminating devices, chiefly of glass .....lbs.	.....	.....	72,764	22,438	.....	.....	665,274	244,259
Chemical glassware .....lbs.	.....	17,419	9,305	6,769	.....	162,049	180,637	92,612
Electrical glassware, except for lighting.....lbs.	.....	.....	280,545	15,326	.....	.....	1,034,242	91,785
Other glassware, n. e. s.....lbs.	.....	393,564	632,029	110,567	.....	5,649,546	8,763,916	1,041,070